STATE OF NEW YORK
DEPARTMENT OF CONSERVATION
WATER POWER AND CONTROL COMMISSION

THE GROUND-WATER RESOURCES OF SCHOHARIE COUNTY, NEW YORK

By

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Prepared by the
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THE GROUND-WATER RESOURCES OF SCHOHARIE COUNTY, NEW YORK

By JEAN M. BERDAN

ABSTRACT

The U. S. Geological Survey, in cooperation with the New York Water Power and Control Commission, investigated the ground-water resources of Schoharie County during 1946 and 1947. This report is based on records of more than 800 wells and springs, logs of approximately 65 wells, partial chemical analyses of water from 40 wells, and a study of the geology of Schoharie County.

Schoharie County is situated in east-central New York, and is about 30 miles west of the City of Albany. The principal occupation of the County is dairy farming. Most of the industrial establishments are milk processing plants.

The County extends from the Mohawk Valley physiographic province on the north to the northern ranges of the Catskill Mountains in the south. The northern part of the County is a westward continuation of the Helderberg escarpment and is predominantly a dissected limestone plateau. The southern part is a higher dissected plateau lying at an elevation of approximately 2,000 feet. This plateau extends to the southernmost part of the County, to the Catskill Mountains. The topography has been modified by glaciation.

The bedrock consists of sedimentary rocks which dip to the south at about 100 to 135 feet to the mile. These rocks are traversed by three sets of joints which strike roughly N. 57° W., N. 29° W., and N. 55° E.

The rocks in the County range in age from Middle Ordovician to Upper Devonian time. The rocks of Middle Ordovician age are chiefly sandstones and shales, the rocks of Upper Silurian and Lower Devonian age are chiefly massive and shaly limestones that are capped with sandstone and siltstone, and the rocks of Middle Devonian age consist of a thick limestone at the base which is capped by a great thickness of shale, sandstone and siltstone. The rocks of Upper Devonian age are predominately sandstones. About three-quarters of the County including the high plateau and the Catskill Mountains is underlain by the sandstone and siltstone of Middle and Upper Devonian age.

In the bedrock, ground water is contained in joints, fractures, and bedding planes rather than in the original pore space in the rock. In the massive limestone in the northern part of the County these openings have been enlarged by solution, producing sink holes and caves. In areas where these limestones crop out extensively much of the drainage is underground through caverns. Several large springs are also associated with the cavernous limestones. The average yield of wells in the rocks of Middle Ordovician, Upper Silurian, and Lower Devonian age is less than 10 gallons a minute, although some wells intersecting enlarged joints in the limestones yield considerably more. The average yield for rocks of Middle and Upper Devonian age is somewhat greater being about 15 gallons a minute. Sufficient water for domestic and farm purposes usually can be obtained from drilled wells tapping bedrock at depths of about 250 feet or less.

The unconsolidated deposits in the County consist of alluvium and glacial debris, the former being limited to narrow belts bordering the streams. The glacial deposits consist of (1) a widespread blanket of till covering the uplands, and occurring in many of the valleys, (2) lake clays in the Schoharie and Cobleskill Valley, and (3) beds of stratified sand and gravel in the Catskill Valley, the Manorkill Valley, the Broome Center area, and the Jefferson area. The alluvium, because of its limited extent, is not an important source of water in the County.

Dug wells in the till usually yield sufficient water for domestic and farm use. Because of its impervious character, the lake clay is chiefly important because in the Cobleskill Valley it acts as a confining bed in a local artesian basin, and in the Schoharie Valley and possibly other areas it inhibits recharge to water-bearing gravels lying beneath it. The beds of glacial sand and gravel are potential sources of large supplies. In the Schoharie Valley such gravels occur beneath the lake clays.

Water from wells in the areas underlain by limestone is generally hard, and in places contains other objectionable mineral constituents. The famous mineral springs at Sharon Springs flow from such rocks. The water from wells in the Middle and Upper Devonian shales and siltstones is generally not as hard, especially in the upland region, but in the Schoharie Valley water from deep wells in these rocks is similar in composition to that from wells in the limestone region. The quality of water from wells in the glacial drift varies from place to place and appears to depend on chiefly the mineral constituents of the drift.

Ground water is utilized in Schoharie County for practically all individual domestic supplies and at least in part for six out of eight public supplies. Adequate supplies for domestic and farm uses may be obtained almost anywhere in the County from dug wells tapping the glacial drift or from drilled wells tapping the coarser glacial deposits or bedrock. No large yielding wells have been developed in the County, and it is doubtful that large supplies can be developed from the bedrock, till, and clay. It is possible that large supplies may be developed from beds of stratified sand and gravel in the southern part of the County and in the Catskill Valley. The presence of thick deposits of clay in the Schoharie and Cobleskill Valleys suggests that the chances of obtaining a large permanent supply in these areas are poor.

INTRODUCTION

PURPOSE, SCOPE, AND METHODS OF INVESTIGATION

In December of 1945 the U. S. Geological Survey began an investigation of the ground-water resources of Schoharie County as a part of a statewide survey being carried on in cooperation with the New York Water Power and Control Commission. The purpose of the studies is to determine the quantity and quality of ground water available in the State of New York in order to facilitate a fuller utilization and conservation of the resources of the State. The areas in which ground-water studies have been completed and in which work is now in progress are shown in figure 1. Reports have been published for Albany, Monroe, and Rensselaer Counties and for parts of Broome and Cortland Counties; and reports for Columbia, Delaware, Fulton, Greene, Montgomery, Schenectady, Washington, Wayne and Seneca Counties are being prepared.

This report presents the results of a study to determine the occurrence, availability, and quality of ground water in Schoharie County, during the course of which records for approximately 800 wells and springs were collected and samples of water from 40 wells were analyzed for mineral content. The locations of all wells and springs for which records are given in this report are shown on plate 1, except for wells numbered So 608 to So 651 in table 6, and 2 springs, So 109Sp and So 139Sp in table 4 which were collected after Plate 1 was printed.

The wells have been numbered in order beginning with number So 1, and springs have been numbered in a separate series beginning with number So 1Sp. Although the prefix "So" signifies that the particular well or spring is located in Schoharie County, its use was considered unnecessary in plotting wells and springs locations on plate 1 as the plate covers only Schoharie County. As an aid in reporting a well or spring location anywhere in New York State the entire state has been arbitrarily divided into a system of rectangles, each one of which covers 15 minutes of longitude and 15 minutes of latitude. The meridian lines forming the vertical sides of the rectangles have been lettered consecutively across the State from west to east, beginning with "A" and ending with "Z". The parallels of latitude forming the horizontal sides of the rectangles have been numbered consecutively across the State from north to south, beginning with "1" and ending with "17". These "coordinate" letters and numbers appear in the margins of plate 1 opposite the appropriate meridians and parallels of latitude. In the tables of well and spring records each location is detailed by giving first the coordinates of one corner of the rectangle concerned, followed by two other number-and-letter combinations that indicate the distance in miles and directon from the designated corner of the rectangle to the well or spring being located. For example, well So 214 (10V, 1.2S, 2.8E) will be found 1.2 miles south and 2.8 miles east of the intersection of lines 10 and V.

It has not been possible to check in the field the exact location of some of the wells. In many cases only incomplete records were available from well drillers and owners. Although a few well-drilling firms keep excellent records, a considerable number of drillers only keep records of the depth of wells and lengths of casing used. In these cases other details of construction are reported from memory, if at all. In general, little attention is paid to unconsolidated materials overlying the bedrock. The necessity for detailed information about subsurface conditions for the economic development of ground-water resources, as well as for construction purposes, makes it advisable for well-drillers to maintain complete and accurate records. By so doing they will render a valuable service to the people of the State as well as to their own profession.

ACKNOWLEDGMENTS

The author wishes to acknowledge the generous assistance of the many officials of federal, state and municipal agencies, as well as numerous well drillers, residents of Schoharie County, consulting engineers, and geologists, who supplied valuable information for use in this report. Among the state agencies contributing information are the New York Department of Commerce, the New York Water Power and Control Commission, and the New York State Health Department, which analyzed water samples and supplied data on public water supplies.

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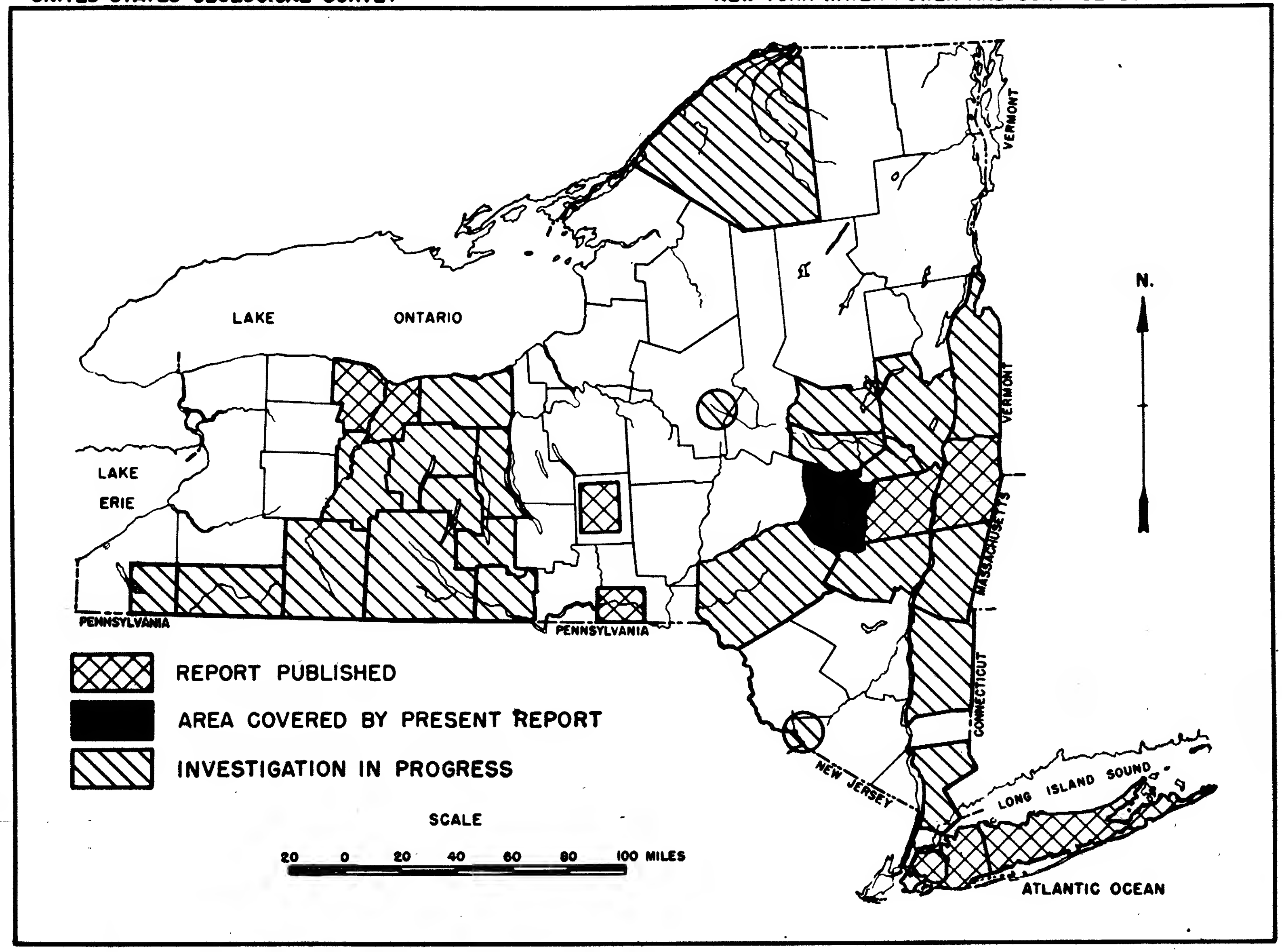

Figure 1.—Index map of New York showing areas of cooperative ground water studies.

The author is especially grateful to Dr. Winifred Goldring, State Paleontologist of the New York State Museum for help in interpreting the geology of Schoharie County, and to Mr. Alvin Whitney for providing publications of the New York State Museum. Assistance given by Dr. G. A. Cooper of the U. S. National Museum concerning the rocks of Middle and Upper Devonian age is greatly appreciated, as is also the help given by Professor R. F. Flint of Yale University in interpreting the glacial geology of the County. Mr. R. W. Armstrong, Chief Engineer of the New York City Board of Water Supply kindly supplied records of the borings for the Gilboa Dam. Among the well drillers who cooperated in providing well logs are Mr. H. W. Provost, Mr. John Van Loan, Hall and Company, Inc., Mr. J. S. Stewart, and the Fick Brothers. Thanks also are due to the many public officials of the municipalities who supplied data on the public water-supply systems, especially Mayor Badgely and Mr. Edward Manchester, water superintendent of Schoharie, Mayor C. M. Bullock of Sharon Springs, Mayor Karker and Mr. Les Shaver, water superintendent, of Cobleskill, Mr. Howard Cornwall, superintendent, and Mr. Jacob Enders of the Central Bridge Water Company, and Mr. Harmon McMain, superintendent of the Middleburg water supply. Mr. R. Veenfliet gave assistance in the exploration of Clarks Cave situated on his property.

Further acknowledgments are gratefully made to colleagues in the Geological Survey, particularly E. S. Asselstine, for suggestions provided during the preparation of the report. Water samples and well and spring records used in the report were collected by E. J. Podgorski, Henry Paige, W. S. Winslow, V. H. Rockefeller, and others. Messrs. Clayton H. Hardison and Oliver P. Hunt, Engineers of the Surface Water Branch, determined the loss of water from Cobleskill Creek into the Coeymans limestone by gaging Cobleskill Creek. This report was prepared under the supervision of M. L. Brashears, Jr., District Geologist, in charge of ground-water investigations in New York and New England.

PREVIOUS REPORTS AND INVESTIGATIONS

The Schoharie Valley is one of the classic regions of New York State geology, and because of the excellent exposures of rocks and fossils, many papers have been published on the paleontology and stratigraphy of the area. A list of those published prior to 1906 is given by Grabau in New York State Museum Bulletin 92. New York State Museum Bulletin 303 contains a map by Goldring covering the eastern part of the County, and this and the map in Bulletin 92 have been used as the basis for the geologic map (pl. 2) in this report. Information on the western and southern parts of the County is given in papers by Cooper, and by Goldring and Flower. (references). The glacial geology of the southern part of the County is given by Rich in New York State Museum Bulletin 299. The above mentioned reports and others are given in the list of references in this report.

GEOGRAPHY

LOCATION AND CULTURE

Schoharie County is situated in east-central New York (figure 1), and has an area of 620 square miles. The principal incorporated towns are Schoharie, the county seat, with a population of 941 in 1940; Cobleskill, with a population of 2,617; Middleburg, with a population of 1,074; Richmondville, with a population of 598; Sharon Springs, with a population of 433; and Esperance, with a population of 219. There are, in addition, more than 50 small unincorporated villages.

The principal occupation is dairy farming, 47 percent of the employed persons in the County being farmers or agricultural workers, the highest percentage of any county in New York. In 1940 there were 2,543 farms in the County, of which 89.5 percent were owner-occupied. The principal crops are hay, alfalfa, oats, and other fodder crops, although some hops are still grown in the Schoharie Valley, which was formerly a famous hopgrowing district. Also, there are a number of orchards in the northern part of the County. In 1939 there were only 20 manufacturing establishments and 12 wholesale establishments in the County, the towns being principally market centers for the farmers in the surrounding regions. The only industries employing more than 25 people are situated in and around Cobleskill, and include dress and refrigerator manufacturing. At present three limestone quarries

are being operated in the County, the largest being the plant of the North American Cement Corporation at Howes Cave, where the Coeymans and Manlius limestones are quarried for cement. The Cushing Stone Company at Schoharie also quarries the Coeymans and Manlius limestones, largely for use as agricultural stone and road metal. The Masick quarry, in the Onondaga limestone south of Schoharie, produces largely agricultural stone. There are eight milk processing plants in Schoharie County, situated at Cobleskill, Central Bridge, Middleburg, North Blenheim, Manorkill, Richmondville, and Seward.

Schoharie County is served by the Delaware and Hudson Railroad, whose main line crosses the northern part of the County in the valley of Cobleskill Creek. A branch line traverses the valley of West Creek from Cobleskill north through Sharon Springs. The Cherry Valley turnpike, U. S. route 20, crosses the northern part of the County east to west. State route 7 also crosses the County from east to southwest, following the Cobleskill Valley, and State route 145 crosses the County diagonally from southeast to northwest, joining U. S. route 20 at Sharon. State route 10 runs north-south across the uplands, joining State route 7 at Richmondville. State route 30 runs north-south through the Schoharie Valley (pl. 2).

TOPOGRAPHY AND DRAINAGE

Schoharie County is an area of considerable relief. It includes parts of the Catskill Mountains in the south and the low-lying Mohawk Valley in the north. The altitude of the land surface rises from north to south, passing from an area of relatively low hills along the Mohawk to a high upland and then into the northern spurs of the Catskill Mountains (fig. 2).

The low rolling hills south of the Mohawk Valley occupy the northern third of the County and lie roughly north of Fox, Cobleskill, and West Creeks. In the east these hills have an altitude of about 1,300 feet above sea level, but in the west, in the vicinity of Sharon Springs, they range up to 1,500 feet. In general, the land in this area produces good crops.

The high upland in the center of the County lies south of the valley walls of the Fox, Cobleskill, and West Creeks and extends southward to the foothills of the Catskill Mountains. It is a high plateau which rises from an altitude of 1,700 feet in the north to over 2,000 feet in the south. Although it has been dissected considerably by streams, its plateau-like nature is conspicuous when viewed from tributary valleys in the uplands. In general the soil in this area is poor, and most of the land is used for pasture land or woodlots. In the southern part of the County, near Manorkill and Jefferson, the Northern and Central escarpments of the Catskills rise to altitudes of over 2,600 feet, 600 feet above the general level of upland plateau. These mountains have been glaciated and have rounded slopes, and are heavily wooded.

As the sedimentary rocks underlying Schoharie County dip southward approximately 100 feet to the mile, or a little more, it is apparent that the major topographic features, especially the upland plateau, or "2,000-foot plateau" as it has been named by Rich,[1] bevel the geologic structure and are not controlled by the altitude of the bedrock (figure 2). It has been generally agreed, therefore, that these features represent former levels of erosion, although their correlation with surfaces in other areas has not been completely determined. The low hills in the northern part of the County generally have been considered to be structurally a part of the "2,000-foot plateau", which has been eroded more rapidly because it is underlain by less resistant rocks. These hills are underlain chiefly by limestones and shales of Upper Silurian, lower Devonian, and Middle Devonian age, and are the westward continuation of the rocks exposed in the Helderberg escarpment. In this report they have been considered separately because in the northeast part of the County, hills reaching 1,300 feet are developed not only on the limestones but also on resistant sandstones and shales of Middle Ordovician age, and the typical development of the Helderberg scarp is lacking. Further study will be necessary to determine whether the 1,300 to 1,500 foot hills represent an incomplete erosion surface or are due to lithologic control.

The central and larger part of Schoharie County lies in the drainage basin of Schoharie Creek and its tributaries, Fox and Cobleskill Creeks, which flow northward into the Mohawk River. Schoharie Creek flows in a deep valley which is trenched from 500 to 800 feet below the level of the "2,000-foot plateau." This valley is endowed with much beautiful

[1] Rich, John L., Physiography and glacial geology of the northern Catskill Mountains: Am. Jour. Sci., 4th ser., vol. 39, pp. 137-166, 1915.

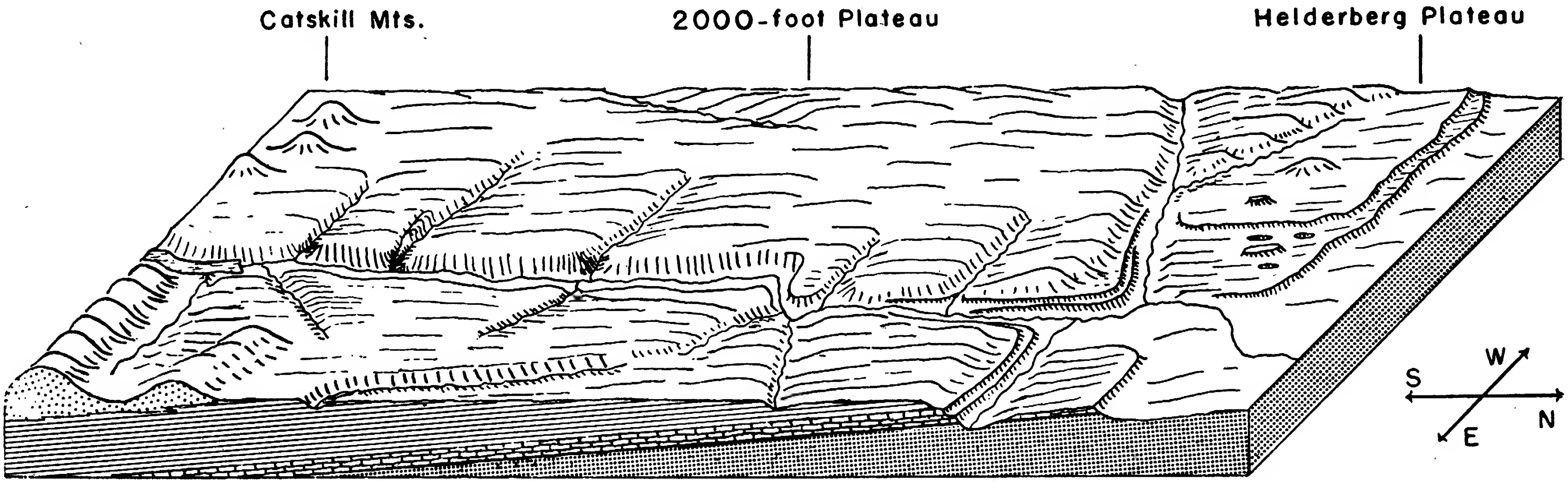

Figure 2.—Generalized diagrammatic sketch showing relation of topography to underlying rocks in Schoharie County, N. Y. Effects of glaciation not shown.

scenery and has been called the "Rhine Valley of America." The valleys of Fox and Cobleskill Creeks are more open, and have been modified by the deposition of glacial drift. A small area in the southwestern part of the County drains through the Charlotte River into the Susquehanna drainage basin, and an area along the southeastern border near Franklinton drains through the Catskill Creek into the Hudson River. The development of this drainage has been thoroughly discussed by Grabau.[2] He considers Schoharie Creek, which flows north perpendicular to the strike of the underlying rocks, as an obsequent stream which developed on a north-facing cuesta scarp, and classifies Fox and Cobleskill Creeks as subsequent streams which developed parallel to the strike, on belts of less resistant rock. The Charlotte River represents a part of the original southwestward drainage consequent on the dip slope of the cuesta, and Catskill Creek represents later obsequent drainage which is cutting into the Catskill Front from the southeast.

Although the major topographic divisions cut across the underlying rocks, minor topographic features are influenced strongly by the character of the underlying beds. As indicated above, these sedimentary formations dip to the south at a low angle, so that the exposed edges of resistant formations appear as steep, north-facing cliffs or scarps, with long, gentle, dip slopes on the south. As most of the resistant formations are relatively thin in comparison to the topographic relief, they tend to appear as "terraces" on the sides of hills rather than as distinct cuestas. This is especially well shown in the hills on both sides of the Schoharie Valley north of Schoharie, where the resistant limestones form cliffs showing the dip parallel to the valley and make prominent "terraces" on the north slopes of the hills. In the vicinity of Carlisle and Little York the limestones form a cliff similar to that of the Helderberg escarpment, with which it is geologically identical. The terraced character of the hills due to alternating harder and softer beds, is not limited to the northern part of the County, underlain by limestones and shales, but is also conspicuous in the higher hills of the "2,000-foot plateau" which are underlain largely by siltstones and shales.

In the area north of Cobleskill Creek and south of Carlisle Center and Grovenors Corners, the presence of limestone formations at and near the surface has modified the drainage, much of which is underground through sink holes and caves in the limestone. In this area, surface streams are short or absent and sinks are common topographic features. It is believed that at least part of this subsurface drainage system is pre-Pleistocene in age.

On the topographic map of the Schoharie quadrangle it may be seen that most of the tributary streams on the west side of Schoharie Creek enter the creek at an angle which is acute downstream, whereas those on the east side of the creek enter at an angle which is acute upstream. There is also a tendency for tributaries from the east and west to enter the main stream opposite each other, and to be aligned in a northwest-southeast direction. It has been suggested by Flint (R. F. Flint—personal communication) that this alignment may be due to a structural control, and the presence of a well-developed system of northwest-southeast trending joints suggests that this may be the feature which controlled the development of the tributaries.

The effect of glaciation on the topography of Schoharie County was chiefly depositional rather than erosional. Before the advance of the Pleistocene ice sheet, the land forms were much as they are today; and although the moving ice smoothed and polished exposed rock surfaces, rounded the hill tops, and deepened the north-south valleys to some extent, it did not greatly change any of the principal features. However, by blocking the Schoharie basin on the north, it formed lakes in the valley of Schoharie Creek in which were deposited beds of clay and coarser materials which modified the topography of the valley. Furthermore, the deposition of a thick blanket of till on the uplands and in the northern part of the County has partly covered the land forms developed on the bedrock and has diverted some of the minor streams.

The most recent change in the drainage of Schoharie County has been the construction of a dam at Gilboa by the City of New York, which has formed a reservoir five miles long. Water is withdrawn from this reservoir, southward through the Shandaken tunnel to the city, instead of flowing northward to the Mohawk River through Schoharie Creek. Diversion of the upper part of the Schoharie and the consequent reduction in flow of the creek, may have caused a reduction in its rate of erosion.

[2] Grabau, A. W., Geology and paleontology of the Schoharie Valley: New York State Mus. Bull. 92, pp. 345-347, 1906.

CLIMATE

There is considerable variation in climate between the valleys and the uplands in Schoharie County. The U. S. Weather Bureau has maintained two stations at Sharon Springs since 1912, and one at Middleburg since 1943. Sharon Springs station 1 is situated 1½ miles east of the town at an elevation of 821 feet above sea level, and is in the Mohawk lowland. Sharon Springs station 2 is 2 miles southwest of the town at an elevation of 1,360 feet above sea level, and is situated on the limestone plateau. The latter is probably more representative of conditions in the County, at least the northern part including the Schoharie Valley. Records for station 1, indicate in general a greater mean annual air temperature and a greater total precipitation than those for station 2. Weather data are not available for the "2,000-foot plateau" or the Catskill Mountain areas, which together include over half of the County, but it is probable that these exposed uplands have a lower mean annual air temperature, and a shorter growing season than those experienced in the northern part of the County, and in the protected valleys. The period of record at Middleburg is too short to be used for more than tentative conclusions.

The mean annual temperature for both weather stations at Sharon Springs for the period 1936 to 1947 is 46°F., the difference between the average mean temperatures for both stations for this period being 1°F. For the five-year period of record for the Middleburg station, 1943 to 1947 the mean annual temperature is about 47°F. The minimum temperature usually falls in January or February, and the maximum temperature may fall in any month from June to September. Maxima of over 100°F. have been recorded twice in the past twelve years in the County, and minima of below —20°F. have been recorded several times in the same period.

The norm of precipitation for the 35-year period of record for both stations at Sharon Springs is about 40.5 inches. Maximum monthly precipitation may occur in any month in the year, but is slightly less likely to occur in winter than in summer. The greatest monthly precipitation for the twelve years ending in 1947 was recorded at Sharon Springs station 1 in September 1938, when 8.92 inches fell. The smallest monthly precipitation for the same period was recorded at station 2 in June 1936, and again in July 1939, when only 0.91 inches fell. At Middleburg a minimum monthly precipitation of 0.18 inches was recorded in September 1943, and during the period 1943 to 1947, the annual precipitation at Middleburg averaged 8 inches less than at Sharon Springs.

The average length of the growing season during the period 1936 to 1947 at Sharon Springs station 2 was about 134 days. The last killing frost in the spring usually occurs in the second week of May and the first killing frost in the fall usually occurs in the last two weeks of September or the first week in October.

Table 1 shows mean annual temperature, maximum and minimum temperature, and annual precipitation, maximum and minimum monthly precipitation, and departures from normal precipitation for the U. S. Weather Bureau stations in Schoharie County from 1936 to 1947.

GEOLOGY

The rocks of Schoharie County are sedimentary in origin. They have been divided into about fifteen formations, which range in age from Middle Ordovician to Upper Devonian. The character, thickness, and water-bearing properties of these formations are shown in table 2. Their areal distribution is shown on plate 2.

GEOLOGIC HISTORY

The record of geologic history in Schoharie County begins with the Middle Ordovician. At that time the County was part of a shallow sea which was receiving deposits of sand, clay, and silt from an adjacent land mass. Ruedemann[3] has shown that these deposits, the Schenectady formation, were laid down in a trough which was sinking at such a rate that, although a great thickness of sediments accumulated, shallow water conditions prevailed throughout the period of deposition.

[3] Ruedemann, Rudolf, Geology of the Capital district: New York State Mus. Bull. 285, pp. 33-37, 1930.

Table 1.—Temperature and precipitation at U. S. Weather Bureau stations in Schoharie County, New York.

Mean annual, and maximum and minimum air temperatures in (°F.)

Year	Sharon Springs 1 Mean Annual	Max.	Min.	Sharon Springs 2 Mean Annual	Max.	Min.	Middleburg Mean Annual	Max.	Min.
1936	47.0	102	—14	45.3	98	—9	..	..	..
1937	47.8	93	0	46.2	90	—1	..	..	..
1938	48.0	94	—23	46.9	92	—17	..	..	..
1939	46.8	96	—15	45.6	94	—12	..	..	..
1940	44.3	94	—14	43.1	91	—11	..	..	..
1941	..	..	..	46.1	92	—7	..	..	..
1942	..	..	..	45.6	90	—23	..	..	..
1943	45.4	92	—27	..	..	..	45.5	96	—23
1944	46.5	96	—18	..	..	..	47.2	101	—9
1945	46.9	93	—15	..	..	..	47.5	98	—12
1946	47.7	95	—12	..	92	—12	48.3	96	—10
1947	46.8	95	—7	..	94	—5	47.6	97	—8

Total annual, maximum monthly, and minimum monthly precipitation in inches and departure from normal.

Year	Sharon Springs 1 Total	Max.	Min.	Dep.	Sharon Springs 2 Total	Max.	Min.	Dep.	Middleburg Total	Max.	Min.	Dep.
1936	41.64	6.42	1.69	+0.72	..	5.70	0.91	..	..	..	..	..
1937	41.74	7.03	1.74	+0.82	43.81	8.90	2.05	+3.72	..	..	..	..
1938	41.89	8.92	1.31	+0.97	38.66	7.07	1.22	—1.43	..	..	..	..
1939	34.22	4.45	0.99	—6.70	29.50	3.29	0.91	—10.59	..	..	..	..
1940	41.65	5.71	1.51	+0.73	39.30	6.22	1.53	—0.79	..	..	..	..
1941	..	..	..	..	29.87	4.13	1.02	—10.22	..	..	..	..
1942	..	..	..	..	50.45	6.63	1.27	+10.36	..	..	..	..
1943	48.45	7.45	1.16	..	..	..	..	..	34.45	5.75	0.18	..
1944	36.99	4.97	1.42	—3.93	38.52	..	..	—1.97	34.13	4.99	1.35	..
1945	50.10	6.82	1.70	+9.18	..	..	..	..	44.20	6.06	1.42	..
1946	38.48	6.64	1.19	—2.52	..	..	..	..	30.80	6.07	0.82	..
1947	43.89	6.44	1.61	+2.96	..	..	..	..	32.82	5.97	1.02	..

Following the deposition of the Schenectady formation, the area was raised slightly above sea level and remained so from Middle Ordovician time until late in Silurian time. It has been suggested by Ruedemann[4] that the Brayman shale, which lies directly above the Schenectady formation may represent a residual soil developed during the interval from Middle Ordovician to Upper Silurian time.

After this period the area once more sank below sea level, and the Cobleskill limestone was deposited. As silt and clay were added to the sea the character of the deposits changed, and the Rondout limestone was laid down. Another change in the conditions of deposition produced the Manlius limestone. All of these formations were apparently laid down in rather shallow water. Following the deposition of the Manlius limestone the area may have been again raised briefly above sea level, and when it was again submerged, deposition of the Coeymans limestone occurred with little change in physical conditions. This slight break in the sedimentary record is considered by many geologists to mark the end of Silurian time, and the beginning of Devonian time. An increase of clay in the sediments deposited resulted in the shaly New Scotland limestone and a subsequent return to clear waters produced the Becraft limestone, which is lithologically similar to Coeymans limestone.

[4] Ruedemann, Rudolf, Lower Siluric shales of the Mohawk Valley: New York State Mus. Bull. 162, pp. 54-58, 1912.

Table 2.—Geologic formations in Schoharie County and their water-bearing properties.

Age: System	Age: Series	Geologic subdivision	Thickness (feet)	Character of material	Water-bearing properties
Quaternary	Recent	Alluvium	20±	Clay, silt, sand, gravel; confined to stream flood plains.	Only sands and gravels are good aquifers. Water may need chlorination.
Quaternary	Pleistocene	Till and stratified drift.	up to approximately 200	Unsorted clayey till, stratified lake clay and outwash sand and gravel.	Till yields small supplies to dug wells. Fine deposits are practically impervious. Sands and gravels yield up to 200 gallons per minute. Quality of water varies greatly.
Devonian	Upper Devonian	Onteora formation	1,000±	Grey, medium to fine-grained sandstone; red and green shale.	Water contained in joints and bedding planes. Many small springs. Average yields approximate 14 gallons per minute.
Devonian	Upper Devonian	Gilboa formation	325	Grey, medium to fine-grained sandstone; thin-bedded siltstone; dark grey shale.	Water contained in joints and bedding planes. Quite a few small springs. Average yields approximately 13 gallons per minute.
Devonian	Middle Devonian	Hamilton Group: Hamilton formation	2,175±		
Devonian	Middle Devonian	Hamilton Group: Marcellus shale	180±	Black fissile shale, weathers rusty, and breaks in plates.	Water in joints and bedding planes. Average yield 10 gallons per minute. Water has greater concentration of dissolved minerals than Gilboa and Hamilton formations.
Devonian	Lower or Middle Devonian	Onondaga limestone	100 to 130	Massive, light grey limestone, appears crystalline, contains chert in seams.	Water in joints and bedding planes enlarged by solution. Average yield 18± gallons per minute. Yields are highly variable.
Devonian	Lower or Middle Devonian	Schoharie grit	5 to 8	Hard, sandy, dark grey limestone, weathers to sandstone.	Not important as an aquifer; acts as unit with Onondaga.
Devonian	Lower or Middle Devonian	Carlisle Center formation	20±	Greenish-grey, platy, sandy shale.	Not important as an aquifer, acts as unit with Esopus.
Devonian	Lower or Middle Devonian	Esopus siltstone	80±	Brownish-grey siltstone, breaks into small cubical blocks, very much fractured.	Water in closely spaced joints, average yield about 8 gallons per minute.
Devonian	Lower Devonian	Oriskany sandstone	6 to 12	Light grey, limy sandstone, weathers to porous brown sandstone.	Not important as an aquifer because of limited thickness of formation.
Devonian	Lower Devonian	Becraft limestone	20+	Massive, grey crystalline limestone containing pink calcite, very fossiliferous.	Water in enlarged joints and solution channels. Has several sinks and transmits water to underlying formations. Not important as an aquifer.
Devonian	Lower Devonian	New Scotland limestone	100 to 137	Shaly, drab limestone, hard when fresh, weathers to clay. Has chert, especially in lower part. Very fossiliferous.	Acts in part as unit with Becraft and Coeymans; in part retards passage of water because of its clayey character. Average yield of wells less than 5 gallons per minute.
Devonian	Lower Devonian	Coeymans limestone	50±	Massive, dark brownish-grey crystalline limestone. Very fossiliferous.	Water in enlarged joints and solution channels. Many caves and sinks. Average yield about 5 gallons per minute.
Silurian		Manlius limestone	50±	Thin-bedded, dark blue-grey limestone occurring in heavy ledges.	Acts as unit with Coeymans limestone and is similar in hydrologic behavior.
Silurian		Rondout limestone	60 to 100	Drab, platy, thin-bedded fine-grained limestone and limy shale.	Similar to New Scotland limestone in hydrologic behavior. Average yield of wells about 5 gallons per minute.
Silurian		Cobleskill limestone	6 to 12	Massive, drab, silty and sandy dolomitic limestone.	Not important as aquifer to wells, but source of many springs at contact with underlying beds.
?	?				
Ordovician	Upper Ordovician?	Brayman shale	20 to 40	Olive green clay shales commonly containing pyrite.	Not important as aquifer, but cause of springs at base of Cobleskill. Presence of pyrite affects quality of water.
Ordovician	Middle Ordovician	Schenectady formation	2,000±	Brown to buff sandstones; dark grey shale.	Water contained in joints and along bedding planes. Poor aquifer. Average yields about 5 gallons per minute, quality of water often poor.

After deposition of the Becraft limestone, there was a third period of uplift with resultant erosion of some of the underlying beds. When the sea next advanced over the County it deposited a limy sandstone, the Oriskany sandstone. Deposition of this sandstone gave way abruptly to deposition of dark silty clay, now the Esopus siltstone. The Esopus and the overlying Carlisle Center formation are believed by Goldring and Flower[5] to represent deposition in shallow-water, possibly tidal, mud flats. These sandy and silty beds pass gradationally into the Schoharie grit which in turn grades into the Onondaga limestone.

During Onondaga time, the sea spread widely across New York State and a thickness of about 100 feet of limestone accumulated. At the close of Onondaga time the sea may have withdrawn slightly, and when it returned it received silts and muds from nearby rising lands.

The Onondaga is the last thick formation of limestone laid down in the area. The first deposits laid down on the Onondaga were black shales, in which a few beds of dark limestone were included. These beds were formerly known as the Marcellus formation, but it has been shown by Cooper[6] that they represent a mud facies deposited at progressively later times when traced from east to west. The succeeding beds are dark shales, generally iron-stained. As coarser material was added from the rising land masses, and as the shore line advanced toward the south and west, silts were interbedded with the clays until gradually the greater part of the material deposited became siltstone. In Schoharie County deposition was almost continuous and it is very difficult to separate rocks of Middle and Upper Devonian age. By the end of the Middle Devonian most of the material laid down in the eastern part of the County was continental in origin, and during the Upper Devonian, delta deposits encroached further and further westward until they completely covered the County.

The delta deposits represented by the red shales and coarse sandstones of Upper Devonian age are the youngest consolidated rocks in Schoharie County. It is not known whether Mississippian, Pennsylvanian, and Permian deposits were laid down in Schoharie County and later removed by erosion, or whether the Schoharie region was already being eroded during these periods. The rocks of Schoharie County were too far west to be involved in the mountain building of the Appalachian Revolution at the end of the Paleozoic era, but Parker[7] has discussed reasons for believing that the joints in the sedimentary rocks of eastern and central New York were developed during the early stages of the Appalachian Revolution before the folding and faulting took place.

During the Mesozoic era and the Tertiary period, Schoharie County was above sea level and it is believed that Schoharie Creek and the other principal streams of Schoharie County were established in essentially their present courses by the end of Mesozoic time.

During the Pleistocene a great continental ice sheet advanced over the County, completely covering the tops of the highest mountains. As it moved down from the north, it disrupted the existing northward flowing streams and changed minor features of the landscape by widening the north-south valleys and burying the east-west valleys with deposits of glacial drift. The valley of Schoharie Creek, which had been cut to a depth of over 100 feet below its present surface, was partly filled with clays deposited in lakes ponded in the valley by the ice sheet.

There are two theories concerning the manner of the disappearance of the ice sheet in eastern New York. One, supported most recently by Rich[8] assumes that the ice front retreated northward by melting because melting at the ice front was greater than the rate of ice flow southward. Deposits formed by this type of ice-retreat include moraines of long ridges of unsorted glacial debris parallel to the ice front, and outwash plains or beds of stratified sand and gravel deposited by streams flowing from the ice front. The valleys of the northward-flowing streams were dammed by the ice and contain lake-deposited clays. Proponents of this theory have explained the absence of continuous moraines in eastern New York as due to the topographic relief, and have considered morainal deposits in the valleys to be equivalent to terminal moraines.

[5] Goldring, Winifred, and Flower, Rousseau H., Restudy of the Schoharie and Esopus formations: Am. Jour. Sci., vol. 240, pp. 690-694, 1942; discussion by authors, vol. 242, p. 340, 1944.
[6] Cooper, G. A., Stratigraphy of the Hamilton group of New York: Am. Jour. Sci., 5th ser., vol. 19, pp. 116-134, 214-236, 1930.
[7] Parker, John Mason, III, Regional systematic jointing in slightly deformed sedimentary rocks: Geol. Soc. America Bull. Vol. 53, pp. 381-408, 1942.
[8] Rich, John L., Glacial geology of the Catskills: New York State Mus. Bull. 299, 180 pp., Dec. 1934.

The second theory of the disappearance of the ice, as proposed by Cook[9] and Flint[10], is that the ice sheet lost power of movement, became stagnant and dissipated in place. The deposits associated with this type of dissipation are irregular, hummocky mounds of stratified sands and gravels, kames, which were laid down around and over blocks of melting ice, and paired terraces in valleys with irregular slopes showing deposition against ice masses. According to this concept, the ice melted first from the hills and highlands leaving long tongues of stagnant ice blocking the valleys, and lakes formed beside and over these tongues. One important feature of the stagnation hypothesis is that all the deposits in a wide area show roughly the same amount of dissection by post-glacial streams, whereas according to the hypothesis of gradual melting the most southerly deposits, having been exposed first, are the most dissected. Because of the absence of continuous moraines and related features, and the presence of features suggesting stagnant ice, it is believed that in Schoharie County the ice had ceased to move before its dissipation. As the ice melted back at the end of the Pleistocene, the County assumed its present appearance, the amount of erosion since that time having been relatively minor.

GEOLOGIC STRUCTURE

The geologic structure of Schoharie County is relatively simple. The rocks dip to the southwest at about 100 feet to the mile in the eastern part of the County, and at about 135 feet to the mile in the Schoharie Valley and the western part of the County.[11] As a result, the oldest beds are exposed in the northern part of the County, and the formations are progressively younger toward the south.

A few minor faults are exposed in Schoharie County. There is one along U. S. Route 20 west of Sharon Springs near the county line, which cuts across the Carlisle Center formation, and another about a mile north of the bridge across Schoharie Creek at North Blenheim, on the west side of the creek. This fault is in thick bedded sandstones and shales, has a small displacement, and dies out along a shale bed. It is probable that there are other small faults in the County which have not been recognized due to the cover of glacial drift, especially in the sandstones and shales of Middle Devonian age.

The sedimentary rocks in Schoharie County are cut by several sets of joints. These fractures are of considerable importance to the occurrence of ground water in Schoharie County, as most of the consolidated waterbearing formations have little original pore space, and the ground water exists only in joints and bedding planes. The direction of the joints and the dip of the beds, therefore, influence the movement of ground water, and the spacing of the joints affects the quantity of water held in the rocks and the amount recoverable by wells.

The directions of joints were determined at about 40 localities in various formations in Schoharie County. The joint directions have been plotted on the diagrams shown in figure 3. The joints in the massive limestones are usually vertical and spaced from one to three feet apart, whereas the joints in the shales and siltstones of Middle and Upper Devonian age may dip a few degrees from the vertical and are generally more closely spaced. The joints in siltstone and shale may change direction of both dip and strike and have been plotted separately from the joints in limestone. As may be seen from the diagrams, there are three sets of joints, with average strikes in the limestones of N. 58° W., N. 23° W., and N. 50° E., in the siltstones of N. 56° W., N. 35° W., and N. 61° E. The most conspicuous difference between the two diagrams is the scattering of the northeast set of joints in the siltstones. The joint measurements for the sandstones in the Schenectady formation were too few to plot separately. In general, joints in the Schenectady fall in the northeast quadrant.

J. M. Parker[12] has made a comprehensive study of the joint systems of central and eastern New York in which data are included on the Berne, Richmondville, and Schoharie quadrangles, which cover the northern part of Schoharie County. He has found that for an area extending from Ithaca to the Hudson Valley the joints may be classified into three sets, the first of which has two components. For the three quadrangles in Schoharie County he

[9] Cook, John H., The disappearance of the last glacial ice sheet from eastern New York: New York State Mus. Bull. 251, pp. 158-176, 1924.
[10] Flint, R. F., The stagnation or dissipation of the last ice sheet: Geog. Rev., vol. 19, pp. 256-289, 1929.
[11] Goldring, Winifred, Geology of the Berne quadrangle: New York State Mus. Bull. 303, p. 8, 1935. Grabau, A. W., Geology and paleontology of the Schoharie Valley: New York State Mus. Bull. 92, pp. 86-88, 1906.
[12] Parker, J. M. III, Regional systematic jointing in slightly deformed sedimentary rocks: Geol. Soc. America Bull. vol. 53, pp. 381-408, 1942.

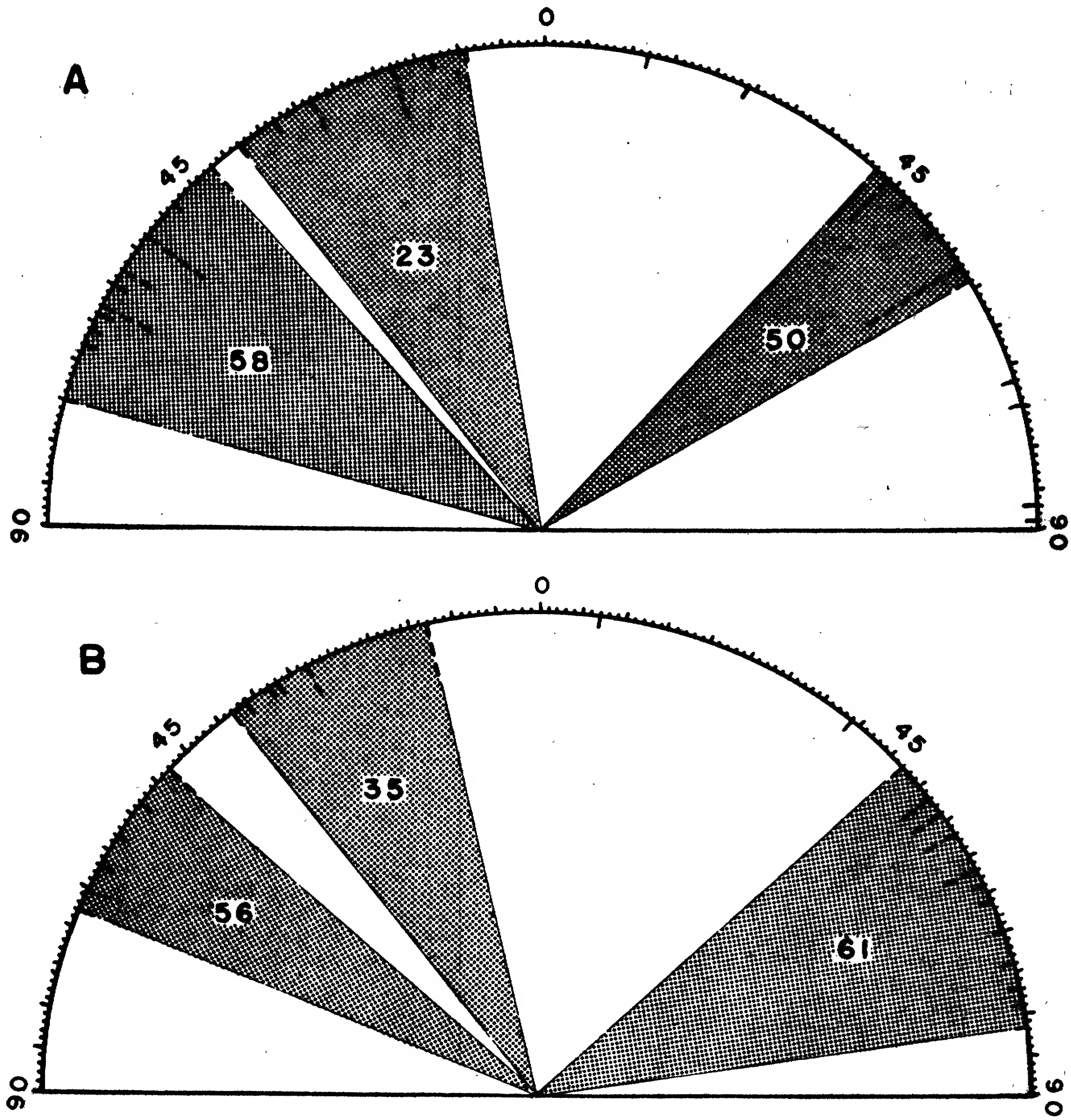

Figure 3.—Diagram showing directions of joints. A, Joints in massive limestone of Upper Silurian to Middle Devonian age; B, Joints in sandstones and siltstones of Middle and Upper Devonian age. Each short line represents joint directions at one locality. Stippled pattern represents joint sets, and figures within joint sets show average strike of joints in each set.

has listed for set I in the Richmondville, Schoharie and Berne quadrangles, respectively, N.-S., N. 25° E., and N. 5° to N. 30° E., the Berne quadrangle being the only one in which both components are given. For set II, he lists N. 55° W., N. 85° W., and N. 50° W., and for set III, N. 50° E., N. 60° E., and N. 65° E. It appears that sets II and III correspond to the N. 56-58° W. and N. 50-61° E. sets shown in figure 3. His set I is not represented in figure 3 and is apparently poorly represented at the localities where the joint readings were made. No readings in this report were made in the Berne quadrangle.

GEOLOGY IN RELATION TO GROUND WATER

Schenectady formation

This formation underlies the northern-most part of the County, and is exposed along U. S. Route 20 from Esperance to Carlisle. West of Carlisle the outcrop belt swings north and underlies Bear Swamp and Argusville, and continues in a strip of lowland along the county line. As may be seen on the geologic map (plate 2) it also underlies the Schoharie Valley as far south as Schoharie, where it is exposed in the creek bed just south of the bridge, the Cobleskill Valley to just east of Braymansville, and the Fox Creek Valley to about a mile east of Gallupville. It also underlies the extreme northeast corner of the County south of Quaker Street.

The Schenectady formation consists of medium to fine-grained sandstones, which commonly weather to a brown or yellowish color, and dark grey, brown-weathering shales. The sandstones are well cemented, and tend to break across the individual quartz grains. Because of their resistant nature, the sandstones are generally better exposed than the shales and in some places have been quarried for flag stones, as in the large quarry on Oak Ridge about 2 miles northwest of Esperance. The shales are frequently used for road metal and are exposed in pits along roads. The sandstones are speckled with limonite on fresh fractures, and are well jointed, the joints in the Oak Hill quarry being N. 70° E., N. 40° E., and N.-S. Fossils are rare in this formation, but those that have been found indicate a Middle Ordovician age and marine deposition under near shore conditions.[13]

The thickness of the Schenectady formation has been estimated by Goldring as being about 2,000 feet.[14] The entire thickness is not exposed in Schoharie County, and to the author's knowledge there are no records of wells in the County which have passed completely through the formation. Because of its great thickness, wells situated on the outcrop of the Schenectady formation do not encounter other rocks, although wells situated on the outcrops of younger beds frequently penetrate the Schenectady formation.

Brayman shale

The Brayman shale overlies the Schenectady formation with a gradational contact. It crops out in a narrow band extending roughly northwest-southeast across the northern part of the County, and extends up into the valley of Cobleskill Creek where it is exposed at Howes Cave, the valley of Schoharie Creek where it is exposed at the old pyrite mine on the property of Mr. Richard Veenfliet, and the valley of Fox Creek where there is an exposure near Gallupville.[15]

Lithologically, the Brayman shale is a clay shale, greenish grey in color, which contains much pyrite. The pyrite was mined for a short while at Schoharie, and its presence is one of the most characteristic features of the shale. Because of its clayey character, the Brayman shale weathers rapidly and is rarely exposed, except in fresh cuts. This feature has made the thickness of the shale difficult to determine, and due to the gradational nature of its contact with the underlying Schenectady formation it is not readily recognized in well logs. Hartnagel has reported[16] a thickness of 40 feet at Howes Cave and a thickness of 27 feet near Schoharie. The thickness at the pyrite mine at Schoharie is probably about 20 feet. At Sharon Springs a thickness of nearly 100 feet of clay shale, similar to the Brayman in appearance but lacking the characteristic pyrite, is exposed north of the village on New York State Route 10. This shale grades into siltstone beds at the base of the section and may be

[13] Ruedemann, Rudolf, Geology of the Capital district: New York State Mus. Bull. 285, pp. 33-38, 1930.
[14] Goldring, Winifred, Geology of the Berne quadrangle: New York State Mus. Bull. 303, pp. 57-58, 1935.
[15] Goldring, Winifred, Geology of the Berne quadrangle: op. cit., p. 77.
[16] Hartnagel, C. A., Preliminary observations on the Cobleskill ("Coralline") limestone of New York: New York State Mus. Bull. 69, p. 1,114, 1903.

a part of the Schenectady formation. Because of the lack of fossils, the age of the Brayman shale has been the subject of much controversy.

Cobleskill limestone

This limestone overlies the Brayman shale with a sharp, probably unconformable contact. It crops out in a narrow band just south of the outcrop of the Brayman shale, and is exposed at many of the same localities, for example, the road cut just west of Howes Cave and the old pyrite mine near Schoharie. Hartnagel[17] has reported a fossil locality in the Cobleskill south of Shutters Corners in the valley of Fox Creek.

Lithologically, the Cobleskill is a dolomitic limestone, drab in color, semicrystalline to fine-grained in texture, and sparingly fossiliferous. It is thick-bedded and heavy-ledged, and because of its resistant character frequently causes a small break in slope between the underlying and overlying weaker rocks. It tends to break along joints into long narrow slabs. Its thickness is about 6 feet at the old pyrite mine and at Howes Cave. A thickness of about 12 feet is indicated in the log of well So 259 (table 5), at Howes Cave.

Rondout limestone

The Cobleskill limestone grades upward, by increase in clayey material, into the Rondout limestone. This limestone crops out between the low terrace formed by the Cobleskill and the cliff formed by the Manlius limestone and the Coeymans limestone, and is best exposed at Howes Cave, where it was formerly mined for cement. It is also exposed in a number of small, abandoned quarries east of the village of Schoharie and in a small road metal pit about 1½ miles northeast of Sharon Center.

The lower part of this limestone, transitional with the Cobleskill, consists of drab to bluish grey, fine-grained, banded, thin-bedded limestones, but higher in the section there are beds with a sandy texture. Part of the limestone is composed of limy shales so thin that they may be classed as paper shales. This phase of the Rondout is extensively exposed in the quarry northeast of Sharon Center. Except for the lower beds, where fossils are sparse, the limestone is practically unfossiliferous. The thickness as recorded by Grabau[18] is about 60 feet, but according to well logs it may be over 100 feet thick near Howes Cave and in the western part of the County.

Manlius limestone

The Manlius limestone crops out along a narrow band in the northern part of the County, extending through Sharon Springs southeast to just north of Carlisle Center and Grovenors Corners, and extends up Cobleskill Creek as far as Braymansville, up Schoharie Creek to about a mile south of Schoharie, and up Fox Creek to more than a mile southeast of Gallupville. It also crops out along the slopes of Barton's Hill. It forms the lower part of the conspicuous limestone cliffs at the entrance to the Schoharie Valley north of Schoharie and along the north side of the Fox Creek Valley, and also the lower part of the line of cliffs just north of Carlisle. It is also exposed in abandoned quarries in the southern part of the village of Sharon Springs, in the quarries of the North American Cement Corporation at Howes Cave and in the Cushing Stone Company quarry at Schoharie, where it is quarried with the Coeymans for cement, agricultural stone, and road metal.

The Manlius limestone is typically a dense, thin-bedded, heavy-ledged limestone, and is dark-grey to black on fresh surfaces, but light blue-grey on weathered surfaces. The thin bedding combined with its massive character causes it to appear laminated in many exposures. It is generally fossiliferous but the fossils are small forms and are usually concentrated along the bedding planes. It is known by quarrymen as "blue stone," as contrasted to "grey stone," applied to the Coeymans limestone. Because of its massive character it forms cliffs. Its contact with the underlying Rondout limestone is gradational, but it is believed by some geologists to be separated from the Coeymans by a slight unconformity which may be seen as an uneven plane of contact in the Cushing quarry at Schoharie, although elsewhere in the County, it is difficult to place. In a few localities the Manlius is semicrystalline and more abundantly fossiliferous, approaching the Coeymans in lithology. Its thickness throughout the County is approximately 50 feet.

17 Hartnagel, C. A., Preliminary observations on the Cobleskill ("Coralline") limestone of New York: op. cit. p. 1,116.
18 Grabau, A. W., Geology and paleontology of the Schoharie Valley: op. cit., p. 111.

Coeymans limestone

The Coeymans limestone rests on the Manlius limestone, and is exposed in much the same area. However, its area of outcrop is considerably larger than that of the underlying Manlius, which it generally covers except along vertical cliff faces. It is exposed at all the localities listed for the Manlius, and, because it forms a terrace surface, is also exposed in many places where the Manlius is not exposed. The Coeymans forms the upper surface of broad terraces from west of Sharon Springs to Little York. South of Little York and Carlisle a belt of lowland containing several sinks is underlain by this formation. A considerable area south of Grovenors Corners is also underlain by the Coeymans. Its outcrop area cuts across Cobleskill Creek at Barnerville, and on the east side of the Creek and in the eastern half of the County the belt of exposures is narrower.

Lithologically the Coeymans limestone is crystalline, grey-brown to dark grey on fresh surfaces, and it weathers to a darker grey than does the Manlius limestone. It is thick-bedded and heavy-ledged, and is a cliff former in conjunction with the Manlius. It is usually very fossiliferous, and contains many crinoid stems composed of crystalline calcite. Throughout Schoharie County the Coeymans is approximately 50 feet thick, the combined thickness of the Coeymans and Manlius being 100 feet. The Coeymans is generally considered the basal formation of the Devonian system.

New Scotland limestone

This limestone overlies the Coeymans limestone with a gradational contact and is exposed to the south of the Coeymans outcrop areas, in road cuts south of Sharon Springs and in a few cuts along U. S. Route 20 west of Sharon. It underlies a considerable area south and east of Carlisle Center and underlies soil-covered slopes in the hills south of Cobleskill Creek and on both sides of the Schoharie Valley as far south as Davis Crossing. It extends up the valley of Fox Creek to about 2½ miles southeast of Gallupville, and underlies part of the slopes of Barton Hill and a considerable area east of Barton Hill, as shown on the geologic map (plate 2).

The New Scotland limestone is a shaly, impure limestone containing considerable clayey material. It tends to break down on exposure, and generally forms soil-covered slopes. Natural exposures are uncommon, and exposures occur only in road cuts and in narrow stream valleys. It is very fossiliferous. The fossils frequently weather free on the surface and are often partly or entirely silicified. In the Schoharie Valley region the lower part of the New Scotland contains chert seams, as does also the upper part of the Coeymans. In the western part of the County, the chert appears to occur throughout the formation and is not confined to the lower part. In the Helderberg area and in the Hudson Valley the cherty beds at the top of the Coeymans and in the lower part of the New Scotland have been considered a separate formation, the Kalkberg, by Chadwick,[19] and in that area these beds form a slight topographic break or low terrace above the Coeymans. The progressive increase in the amount of chert in the New Scotland toward the west makes it impracticable to distinguish the Kalkberg as a separate formation in Schoharie County.

The thickness of the New Scotland in the Schoharie Valley has been reported by Grabau as being 115 feet.[20] Well So 247 passes through a thickness of about 135 feet of New Scotland. Well So 240 logged 112 feet of "shale" which probably represents the New Scotland, but as the well ends in this formation the entire thickness was apparently not penetrated.

Becraft limestone, including Alsen and Port Ewen limestones

The New Scotland limestone passes gradationally upward into the Becraft limestone. This limestone crops out along a narrow strip south of Sharon Springs and in the slopes of the hill west of Sharon Springs, and extends up the valley of Cobleskill Creek. It underlies a considerable area south of Carlisle Center and the extreme eastern part of the County northeast of Gallupville, but on the south side of the valley of Fox Creek it crops out only on the hillslopes.

The Becraft limestone is a gray, crystalline, fossiliferous limestone, which is very similar to the Coeymans in general appearance. Lithologically, it may be distinguished

[19] Chadwick, G. H., Revision of "The New York Series": Science, n. s., vol. 28, pp. 346-348, 1908.
[20] Grabau, A. W., Geology and paleontology of the Schoharie Valley: op. cit., p. 141.

from the Coeymans by its generally lighter color, and the prevalence of white or pink crystalline calcite, although these criteria are not always applicable as these two limestones tend to approach each other in character. Probably the most positive means of identifying the Becraft is by the fossil content. A diagnostic feature of the Becraft in comparison to the Coeymans in this area is its thickness. The Becraft as reported by Grabau[21] is not more than 30 feet thick in the Schoharie Valley. The log of well So 247 (table 5) shows 20 feet of Becraft, and the exposures south of Barnerville and about 1½ miles southeast of Little York also indicate a thickness of 15 to 20 feet. The Becraft is generally covered with drift west of Little York, but the basal beds, transitional with the New Scotland, are exposed in a road cut on U. S. Route 20, about three-quarters of a mile west of Sharon Springs on the north side of the road. At this locality typical beds of massive, crystalline Becraft are interbedded with shaly, cherty New Scotland limestone.

Oriskany sandstone

The Oriskany sandstone lies unconformably on the Becraft limestone. It crops out along a thin, southeast-trending band south of U. S. Route 20, overlies the Becraft in the hill west of Sharon Springs and in the outlier west of Carlisle Center. Other exposures extend down the valley of Cobleskill Creek nearly as far as Cobleskill, down the valley of Schoharie Creek to about half a mile south of Davis Crossing, and down the valley of Fox Creek to the county line. It also lies under the hills north of Fox Creek. It is exposed also in the slopes of Dann's Hill and West Hill, and in a road cut about 1¾ miles east of Schoharie on East Hill, where unweathered fossils may be collected.

The Oriskany is a limy sandstone which is light grey on a fresh surface. It weathers brown and becomes porous as the lime is dissolved away. It contains a conspicuous fauna of large brachiopods. Grabau[22] reports the Oriskany to be about 6 feet thick on West Hill and about one or two feet thick on East Hill. He has suggested also that it may not exist in the Cobleskill Valley area, as on the west side of West Hill the formation is much thinner. However, well So 247 penetrated 10 feet of Oriskany and well So 250, 1½ miles east of Cobleskill, also is believed to have penetrated the Oriskany. The Oriskany is fairly resistant, and in the Schoharie Valley commonly forms a low terrace on the hillsides where it is exposed. The upper surface of this sandstane is characterized by "cock's tail" markings which are believed to represent the fossil burrows of a worm. The Oriskany is not exposed and has not been recognized in wells in the part of the County west of Cobleskill, but is probably present as a thin bed in this area.

Esopus siltstone

The Esopus siltstone underlies a rather narrow belt trending roughly parallel to U. S. Route 20. At Little York the outcrop area trends southeast toward Shutts Corners, from there west to Cobleskill, and then parallels Cobleskill Creek. In the Schoharie Valley the outcrop area extends beside the creek to about three-fourths of a mile south of Davis Crossing on both sides of the valley, and in the valley of Fox Creek it extends to the county line on the south side of the valley, and caps the top of Bartons Hill and the hill northeast of Gallupville. It also crops out in the hill west of Sharon Springs and the outlier west of Carlisle Center. Although the Esopus is not a resistant formation and forms slopes rather than terraces, it is much used for road metal, and exposures are, therefore, fairly common. It is exposed on U. S. Route 20 west of Sharon Springs, just east of the county line, in a large road metal pit on County Route 11 about 1½ miles southeast of Little York, in a small road cut about half a mile west of Carlisle Center, in a pit just below New York Route 7 on the road to Barnerville, and in a number of other localities.

Lithologically the Esopus, usually described as either a shale or a grit, appears in Schoharie County to be better defined as a siltstone. It is composed of quartz fragments which are visible under a hand-lens but are not easily seen with the naked eye. It is drab to brownish grey in color, and characteristically breaks down into small angular chips or blocks on exposure. It is probably this feature which makes it so desirable for use as road metal. Except for occasional worm burrows it is unfossiliferous.

Grabau[23] gives the thickness of the Esopus in the Schoharie Valley as 90 feet on West Hill and about 80 feet on East Hill. Well So 266 about a mile east of East Cobleskill, pene-

[21] Grabau, A. W., Geology and paleontology of the Schoharie Valley: op. cit., pp. 154.
[22] Grabau, A. W., Geology and paleontology of the Schoharie Valley: op. cit., p. 158.
[23] Grabau, A. W., Geology and paleontology of the Schoharie Valley: op. cit., p. 170.

trates 106 feet of Esopus and apparently does not pass completely through it (table 5). All three of these measurements probably include the overlying Carlisle Center formation, as Grabau's thicknesses were based on leveling from the Oriskany to the Schoharie or Onondaga over a covered interval, and the Carlisle Center formation was probably not recognized in the well log. On the road going southwest up a hill about a mile southwest of Little York, partial exposures indicate a thickness for the combined Carlisle Center Esopus formations of about 60 feet, of which at least 15 feet is referable to the Carlisle Center. It is believed that the Esopus siltstone is somewhat thinner in the western part of the County.

Carlisle Center formation

This formation was separated from the Esopus, of which it was formerly considered the upper part, by Goldring and Flower[24] in 1942. Its outcrop belt runs parallel to that of the Esopus in the western part of the County and presumably also in the eastern part, although it has not been recognized in this County east of an abandoned quarry in the Onondaga limestone situated about a mile northeast of Cobleskill. This quarry has been described by Goldring and Flower as the westernmost exposure of the Schoharie grit. The Carlisle Center formation is exposed in the road southwest of Little York and in a cut on U. S. Route 20 about 2 miles west of Sharon Springs, just east of the county line.

The Carlisle Center formation has been separated from the Esopus siltstone on the basis of its lithology and the presence of thin beds of the mineral glauconite at its base and top in the type area. The formation is composed of thin-bedded, greenish-gray, fine-grained sandstones and siltstones, which are generally more coarse-grained than the material composing the Esopus. The beds break in large platy fragments, unlike the small rubbly chips and blocks of the underlying Esopus, and are characteristically covered with the worm-burrow marks, which are generally absent in the Esopus as restricted by Goldring and Flower. It is possible that one reason it is so poorly exposed is because it is relatively weak and does not break into convenient rubble as does the Esopus, and therefore is not quarried for road metal.

Onondaga limestone, including Schoharie grit

The Schoharie grit, the type locality of which is in the Schoharie Valley, is a fossiliferous, sandy limestone that Grabau[25] reports as being 5 to 6 feet thick. The Schoharie has recently been restudied by Goldring and Flower,[26] who have shown that in Schoharie County this grit is a sandy facies of the Onondaga limestone, into which it passes with a gradational contact. This grit is rarely exposed, and as it is unimportant hydrologically, it is here considered the basal facies of the Onondaga.

The Onondaga limestone is exposed in the western part of the County in a large triangular salient along the valley of West Creek. A small outlier of Onondaga caps the hill west of Sharon Springs, and a larger outlier caps the hill west of Carlisle Center. The main outcrop area is continuous from West Creek to the valley of the creek south of Sharon, and extends as a broad belt south of Russell Lake, north of Cobleskill as far as Lawyersville, and west up the Cobleskill Valley nearly to Warnerville. The outcrop belt on the south side of Cobleskill Creek is not as wide, but the Onondaga limestone forms the top of West Hill and extends south in the Schoharie Valley as far as Borst's Mill, about 1 mile north of Middleburg. It crops out continuously along the south side of Fox Creek.

Lithologically, the Onondaga is a dense fine-grained crystalline limestone, usually light grey on both fresh and weathered surfaces, which contains seams of chert nodules, especially in the lower part. It is moderately fossiliferous and contains many corals that in some places give the formation a reefy character. It is well jointed, the joints being three to four feet apart and frequently widened by solution so that the surface is broken into blocks. Grabau[27] believed the Onondaga to be about 100 feet thick in the Schoharie region, but well So 115 at Lawyersville shows a thickness of 136 feet. Well So 240, two miles northeast of Cobleskill, and well So 266, east of Cobleskill, both pass through more than 100 feet of Onondaga limestone.

[24] Goldring, Winifred, and Flower, Rousseau, H., Restudy of the Schoharie and Esopus formations in New York State: Am. Jour. Sci., vol. ?40, pp. 673-694, 1942; discussion by authors, vol. 242, p. 340, 1944.
[25] Grabau, A. W., Geology and paleontology of the Schoharie Valley: op. cit. p. 180.
[26] Goldring, W. and Flower, R. H., Restudy of the Schoharie and Esopus formations in New York State, op. cit. pp. 674-676.
[27] Grabau, A. W., Geology and paleontology of the Schoharie Valley: op. cit. pp. 193-195.

Hamilton and Gilboa formations, including the Marcellus shale

The Onondaga limestone is overlain by a great thickness of shales, siltstones, and sandstones belonging to the Hamilton and Gilboa formations, which underlie the entire County south of the Onondaga outcrop belt, with the exception of an area near the south and southeastern part of the County. These formations have been studied by Cooper,[28] who has correlated them with the type area farther west by certain diagnostic fossils.

Immediately overlying the Onondaga limestone is a thickness of about 180 feet of black, fissile shale, which weathers rusty and which includes a few beds of black, fine-grained limestone containing cephalopods. The contact between these shales and the Onondaga limestone appears to be sharp. These black shales and associated limestones are called the Marcellus shale, which is a member of the Hamilton group. Cooper[29] has shown that the black shales and associated limestones are a facies which was not deposited contemporaneously across the State, and that therefore the Marcellus shale in Schoharie County represents only a part of the Marcellus shale exposed at its type locality.

The Marcellus shale is a very weak rock and consequently is seldom exposed. Grabau[30] has reported several localities in the Schoharie Valley, at one of which the carbonaceous upper beds were mined unsuccessfully for coal. The Marcellus as a whole forms lowlands, in contrast to the overlying, more resistant, silty and sandy beds. The lowlands along the valley of West Creek, and in the vicinity of Gardnersville, Janesville, and Beekman Corners are probably underlain by the Marcellus shale. In the central and eastern parts of the County the Marcellus does not underlie large areas, but forms a low terrace between the Onondaga limestone and younger beds of the Hamilton formation.

The black shales grade upward into dark grey, iron-stained shales which contain silty material. The contact between the two types of rocks is not sharp and is seldom seen, but it may be located roughly by the change in the topography, as the more resistant silty beds hold up steeper slopes. The dark grey shales are exposed in the valley about 1½ miles southwest of East Cobleskill, and along the tracks of the Delaware and Hudson Railroad near Beards Hollow. In both of these localities, the shales are interbedded with siltstones. In the remainder of the Hamilton formation and in the Gilboa formation, siltstone and sandstone beds are abundant. The siltstones are grey, fine-grained rocks which occur in beds about half an inch thick. The sandstones are also grey, generally lighter in color than the siltstones, and are thin-bedded to massive. Both the siltstones and sandstones tend to weather to a brown color, and the sandstones usually are speckled with limonite on freshly broken surfaces.

The lithologic character of the Hamilton and Gilboa formations indicates that they were formed under near-shore and deltaic conditions. Marine fossils are abundant at various horizons, and in some localities they are mixed with plant fragments, which suggest the presence of land. In other beds the only fossils are plant remains, and during the construction of the dam at Gilboa the remains of a forest, with some of the tree trunks still in place, was uncovered. Typically the individual beds are not persistent laterally and they lens into each other in short distances. An exception to this is a "pebble bed" exposed about 1½ miles west of North Blenheim, and at other localities in the Schoharie Valley, which Cooper[31] has recognized as the Portland Point member of the Hamilton group, on the basis of fossils. At Bear Gulch, near Summit, he has been able to trace most of the Hamilton formations exposed further west, and has recognized the Tully formation in Summit Hill. Cooper[32] has defined the Gilboa formation as the rocks between the top of the Hamilton and the base of the red beds. In this connection it should be noted that red beds occur in the Hamilton on Mogehanter Mountain and at the top of the Hamilton in the falls of Manorkill Creek. East of the Schoharie Valley the Gilboa formation is largely replaced by red beds. West of the valley, from Summit to Jefferson, it is lithologically indistinguishable from the underlying Hamilton formation except that it contains a larger proportion of sandstone.

The total thickness of the Hamilton formation, including the Marcellus shale, is believed to be in the neighborhood of 2,500 feet. Cooper[33] gives a figure of 325 feet for the

[28] Cooper, G. A., Stratigraphy of the Hamilton group of eastern New York: Am. Jour. Sci. 5th ser., vol. 26, no. 156, pp. 537-551.
[29] Cooper, G. A., Stratigraphy of the Hamilton group of New York: Am. Jour. Sci. 5th ser., vol. 19, no. 110, pp. 116-134, 1930.
[30] Grabau, A. W., Geology and paleontology of the Schoharie Valley: op. cit. pp. 206-209.
[31] Cooper, G. A., Stratigraphy of the Hamilton group of eastern New York: Am. Jour. Sci., 5th ser., vol. 27, p. 1, 1934.
[32] Cooper, G. A. and Williams, J. Stewart, Tully formation of New York: Geol. Soc. America Bull., vol. 46, pp. 818-821, 1935.
[33] Cooper, G. A., Stratigraphy of the Hamilton group of eastern New York, op. cit., p. 818, 1933.

Gilboa formation in the Schoharie Valley, making a total of 2,825 feet of rock between the Onondaga limestone and the red beds in the Schoharie Valley.

Onteora formation

The red and green shales, and grey sandstones overlying the Gilboa formation in the Schoharie Valley and further east have been grouped by Cooper[34] with the Onteora formation of Chadwick. These continental deposits interfinger with marine beds, and appear at progressively higher horizons from east to west. This is suggested on the geologic map, (plate 2) by the reduction in the area of outcrop in the western part of the County. The boundary shown on the map between the Gilboa and Onteora formations is only approximate because of this interfingering of facies, and does not represent a contact visible in the field. The area south of the boundary is underlain predominantly by red beds and associated continental deposits, although some marine beds may be included, and the area north of the boundary is underlain predominantly by the marine grey shales and sandstones, although some red beds are included.

Lithologically the Onteora formation is very similar to the underlying beds except for the color of the sediments and the general absence of fossils. It is composed of red and green shales and grey sandstones, the latter tending to be somewhat more massive and coarser than those in the underlying formations. Because of the change in facies from east to west, it is difficult to make more than an estimate of the thickness of the Onteora exposed in Schoharie County. It appears probable that in the eastern part of the County it is over 2,000 feet thick, but in the western part of the County south of Jefferson it is probably not more than 800 feet thick, and is possibly thinner.

Glacial deposits

The Onteora formation is the youngest consolidated rock exposed in Schoharie County. Resting upon it and upon all the other bedrock formations is a mantle of unconsolidated material which was deposited beneath and in front of the last ice sheet during the Pleistocene epoch. This ice sheet moved across the County from the northeast toward the southwest, as is indicated by the trend of ovoid hills of glacial drift (drumlins) which were formed beneath the ice parallel to the direction of ice movement. The glacier picked up and transported fragments of the rocks over which it passed, and with the disappearance of the ice sheet this drift or debris was exposed, some of it as deposited directly by the ice, and some of it as deposited by streams flowing from the ice.

The material deposited by the glacier consists of coarse stratified sands and gravels deposited by streams, fine-grained silts and clays deposited in lakes, and glacial till, a heterogeneous mixture of fragments ranging in size from boulders to clay particles. The latter is the most common type of glacial deposit in Schoharie County. Till, or "boulder clay," also locally called "hardpan," was deposited beneath the ice sheet, and is composed largely of fragments of the local bedrock from which it was eroded by the glacier. However, it also contains boulders and cobbles of resistant rock which have been transported by the ice from areas farther north. Thus, although most of the coarse material in the till in Schoharie County is composed of sandstone and limestone, cobbles and pebbles of metamorphic and igneous rock from the Adirondacks are not uncommon. Because of the large amount of shale and limestone exposed in Schoharie County and in the Mohawk Valley to the north, the till in Schoharie County contains much clay. The impermeable clay combined with the lack of sorting of the material of which it is composed makes the till a poor water-bearing formation, and large supplies of water cannot be obtained from it. Because it was deposited beneath the ice, till covers the entire County except where it has been removed by erosion, and is frequently present beneath other types of Pleistocene deposits. On the "2,000-foot plateau", it is in most places less than 30 feet thick, but in the limestone area in the northern part of the County, where it occurs in drumlins, it may be more than 100 feet thick. Thick deposits of till also occur in the valleys of Fox and Cobleskill Creeks.

The beds of stratified sand and gravel represent deposits that were laid down by streams flowing from the melting ice. The outwash may occur as kames and other irregular forms, which were caused by deposition around and over blocks of ice which subsequently

[34] Cooper, G. A., and others, Correlation of the Devonian sedimentary formation of North America: Geol. Soc. America Bull., vol. 53, pp. 1729-1794, 1942.

melted. It may also occur as deltas in glacial lakes or as fill in valleys which carried melt water flowing from the glacier. Due to the coarse-grained constituents and well sorted character, the beds of stratified sand and gravel yield large quantities of water. Stratified drift of the kame type of topography is present only in the southern part of Schoharie County, but beds of outwash lie in the upper part of the valley of Catskill Creek, and glacial deltas and small outwash plains occur in many of the valleys throughout the County.

Clays were deposited in glacial lakes in Schoharie County in still water. The pinkish particles composing some of the clays were derived from the red beds of the Onteora formation. Most of the clay, however, is dark grey or brown in color, tough and greasy looking, and not conspicuously varved. Clay is an extremely poor water-bearing material, and consequently there are few records of wells ending in clay. Those that do, obtain their water from some higher formation. Most of the lake clays appear to be confined to the Schoharie and Cobleskill Valleys.

Alluvium

Along the banks and in the valley flats of the large streams in Schoharie County, such as Schoharie, Fox, Cobleskill, and Catskill Creeks and the Charlotte River, there are deposits of sand and gravel laid down by the streams in post-Pleistocene time. These deposits are narrow and confined to the immediate vicinity of the streams which formed them, and are composed of reworked material derived from till and other glacial deposits.

GROUND WATER

SOURCE

Ground water has been defined by Meinzer[35] as "that part of the sub-surface water which is in the zone of saturation," but it is popularly regarded as the water that is obtained from wells and springs. Although it is pumped or issues from the ground, its source lies in the atmosphere, and essentially all ground water is derived from rain and snow that falls on the immediate area.

That the precipitation is sufficient to meet all demands is shown by the fact that an inch of rain will yield more than 17 million gallons of water per square mile. Thus the average rainfall of 40.5 inches contributes annually about 690 million gallons of water to each square mile of land surface in Schoharie County. This, in turn, indicates that a total of about 427 billion gallons of water falls on Schoharie County each year. Of this, part runs off directly in the streams, a part evaporates or is transpired by plants, and the remainder seeps into the ground and recharges the water table. Although the supply of ground water generally varies directly with the amount of precipitation, other factors also control the rate of recharge. If the temperature is very high the rate of evaporation materially decreases the potential supply of ground water. If, on the other hand, the temperature is so low that the ground is frozen, an unusually high percentage of the water, finding its descent blocked, runs off directly into the streams. During the growing season the demands of vegetation, both natural and cultivated, make heavy inroads into the ground-water supply.

OCCURRENCE

All rocks, regardless of their density, contain some pore spaces. Only those pores which are large enough, however, can release water to springs and wells tapping the rock. The amount and size of the openings vary with the character of the rock, and the yields of wells are therefore directly related to the type of rock tapped. The percentage of total rock volume that is occupied by open spaces is a measure of the porosity of a rock. According to Meinzer,[36] the porosity of a sedimentary deposit depends chiefly on (1) the shape and arrangement of its constituent particles, (2) the degree of assortment of its particles, (3) the cementation and compaction to which it has been subjected since its deposition, (4) the removal of minerals through solution by percolating waters, and (5) the fracturing of the rock, resulting in joints and other openings.

[35] Meinzer, O. E., The occurrence of ground water in the United States: U. S. Geol. Survey Water-Supply Paper 489, p. 38, 1923.
[36] Meinzer, O. E., The occurrence of ground water in the United States: op. cit., p. 3.

Although the porosity of a rock indicates the total volume of pore space available for storing water, it is necessary to use a term called specific yield, that indicates the amount of water that will drain out of a rock because of the action of gravity. The specific yield of a rock or soil, with respect to water, is the ratio, expressed as a percentage, of (1) the volume of water which, after being saturated, it will yield to gravity to (2) its own volume. It is a measure of the water that is free to drain out of a material under natural conditions. The value for the specific yield of a rock or soil will be less than the value for porosity since capillary forces will prevent the draining, by gravity, of all the interstices or pore spaces. In addition to specific yield, the term hydraulic permeability must be introduced to indicate the capacity of the rock or soil for transmitting water under pressure. This term, however, is useful primarily when dealing with uniform, unconsolidated deposits, and should be used cautiously (if at all) when the aquifer is an indurated rock which transmits water only through fractures or solution planes. In general, the smaller the interstices of a material the lower will be its specific yield and hydraulic permeability. Thus, clays and silts, which usually have higher porosities than sands or gravels, will yield considerably less water.

The water table is an irregular plane immediately below which all rocks are saturated with water. The source of this water is rainfall which percolates down from the surface. The water table is influenced by but does not exactly reproduce the configuration of the surface topography. Depth to the water table, below the land surface, varies seasonally and annually with variations in precipitation, runoff, withdrawals by wells, temperature, and other related factors.

Under normal water-table conditions water will rise in a well to a height corresponding to that of the water table. When a water-bearing bed is overlain by impermeable beds which serve to confine the water under pressure, an artesian system is created and water will rise in the well to a level other than that of the water table, and in some cases will flow out of the well.

Schenectady formation

Ground water occurs in the Schenectady formation in the joints and bedding planes of the sandstones and shales. Because of the well-cemented character of the sandstones there is little original pore space remaining that might store or pass water. Drilled wells that penetrate the Schenectady formation generally obtain sufficient water for domestic purposes at depths between 100 and 200 feet, although a few wells are as much as 300 or 400 feet deep. The average depth of 27 wells in this formation was 156 feet. The average yield of 20 wells was 5.4 gallons a minute, and in many cases the yield is reported as being only one or two gallons a minute. Well So 421 (table 6) is reported to yield as much as 60 gallons a minute, but this is believed to be exceptional. Most of the wells for which records are available were drilled for household use, and the low yields are in part determined by the type of pump installed and the small amount of water needed, but it is doubtful that yields of much over 20 gallons a minute could be obtained from this formation because of the low permeability of the rocks. Several wells flow at the land surface, all of these being located on low ground, so that the water, which enters the rocks at a higher altitude up the dip of the beds, rises in the wells under pressure. The flows recorded are not greater than 5 gallons a minute.

Brayman shale, Cobleskill limestone, and Rondout limestone

The Brayman shale does not yield water freely to wells, and there are no records of wells which obtain water from it. However, because of its impermeable character, its contact with the overlying Cobleskill limestone is marked by a line of springs. It is believed that in addition to influencing the location of springs, the pyrite in the shale, in some cases, affects the quality of the water. It is probable that the mineral springs at Sharon Springs are due, at least in part, to this relationship, the iron and sulfur in the water being derived from the pyrite in the Brayman, and the magnesia from the dolomite in the Cobleskill. A spring just west of the village of Howes Cave, So 41Sp (table 3), issues from the Cobleskill at its contact with the Brayman, and is reported locally to be the outlet of the water in Howes Cave and to fluctuate with the water in the lake in the cave. This spring supplies a watering trough and yielded more than 20 gallons a minute in July of 1946 even during lengthy periods of little rainfall.

Because of its thinness, the Cobleskill limestone is not an important source of water; there being no records of wells which obtain water solely from this limestone. However, it is the lowest of a group of limestones, shaly limestones, and limy shales which appear to act

in many ways as a hydrologic unit in transmitting water. That is, water which has entered sinks in the Coeymans or higher formations may be transmitted through the underlying formations and emerge through the Cobleskill as in the case of the spring at Howes Cave. The average depth of 8 wells penetrating the Rondout limestone and Cobleskill limestone is 144 feet, and the average yield of the 4 wells for which records are available is about 5 gallons a minute. Although the Rondout acts in part as a hydrologic unit with the Cobleskill, in some localities the shaly beds in the Rondout impede the circulation of ground water and springs occur near its upper contact. One example of this is spring So 45Sp (table 3) which is one of the two springs forming the public supply of the village of Schoharie. This spring issues from the contact of the Rondout and the overlying Manlius, and apparently developed along bedding planes and joints in the latter limestone until forced out along the less soluble beds. The source of the water in this spring is not known, but it may enter through sinks in the Manlius limestone and Coeymans limestone on Barton Hill north of the spring. This spring fluctuates greatly depending on precipitation. Clark's Cave, located on the property of Mr. R. Veenfliet at Schoharie on the west bank of Schoharie Creek is an outlet of ground water through the Rondout limestone. This cave, although generally nearly dry during the summer months, is the outlet of a considerable volume of water in the spring. It is a roughly tubular cavern and not clearly related to the joint system in the limestone as are many of the larger caves of the County.

Manlius limestone and Coeymans limestone

These two limestones, because of their dense texture, contain water only in joints and along bedding planes. These joints are commonly spaced three to four feet apart, and are frequently enlarged by solution. The Manlius limestone and Coeymans limestone act as a unit in the transmission of ground water. Over much of its outcrop, the Coeymans provides the intake area for water which eventually passes through the Manlius and, in some cases, the Rondout and Cobleskill limestones. Where the Coeymans limestone is exposed at the surface, the joints have frequently been so widened by solution that the outcrop is broken into blocks or strips separated by cracks 6 inches to 1 foot wide, and in such areas the land is valueless for either crops or pasture and has been left as wood lots. The top of the cliff north of Carlisle and Little York is an example of this development. The Coeymans and Manlius together contain the large caves in the County, and as might be expected, the Coeymans also contains most of the large sinks which presumably connect with the caves and feed the springs in the lower limestones. One of the largest of these sinks is McPhail's Hole, about half a mile north of Carlisle Center, which is a roughly H-shaped opening developed by solution along joint cracks, and which appears to be over 70 feet deep. It is reported locally that the "Hole" received its name because a school teacher named McPhail was killed exploring it. Ice Cave, also about half a mile north of Carlisle Center, is another sink in the Coeymans. A series of shallow sinks about 1½ miles north of Shutts Corners, which absorb the surface drainage from the lowland between Russell Lake and Carlisle Center, are also in the Coeymans limestone, as are the related sinks south of Little York. About half a mile south of Shutts Corners, on the Shaw farm, there are two large springs which emerge in round pools, one of which is in the bottom of a funnel-shaped depression. Unfortunately there is no bedrock exposed on the farm, the whole area being blanketed by glacial drift. These two springs are believed to be the outlets of the sinks north of Shutts Corners and possibly the outlets of those north of Carlisle Center. It is reported locally that sawdust from a mill situated near the former sinks appeared in these springs. A small stream, tributary to Cobleskill Creek which flows southwest to drain the area north of Shutts Corners, apparently crosses the underground drainage which flows southeast to emerge in the 2 springs. The southwest-flowing stream may have developed on relatively impervious till following the Pleistocene glaciation, and may be superimposed on pre-existing drainage underground through the limestones.

The area south of Carlisle Center and Grovernor Corners has few surface streams, and these few are small and short. This limestone plateau is apparently drained largely through caves such as Howe Caverns and Secret Caverns, both of which are located on it. There is no information available as to the source of the stream that flows through Howe Caverns, or as to the outlet of the stream in Secret Caverns, and it is possible that they are parts of the same water course. However, it should be noted that Secret Caverns is north and slightly east of Howe Caverns, whereas the sinks developed in the drainage to the west are along joints striking about N. 35° W. This direction is well developed in Howe Caverns, and is in line

with the spring which is supposed to represent their outlet. It might also be noted that the sinks north of Carlisle Center are along this line.

At Barnerville, Cobleskill Creek flows across ledges of the Coeymans limestone, into which it loses water by flow along enlarged joint cracks. In the latter part of August 1946, the Surface Water Branch of the Geological Survey measured the flow of the creek above and below the outcrop of the limestone, and it was discovered that a flow of 3.5 cubic feet per second (about 1,550 gallons a minute) was reduced to a flow of 0.15 cubic feet per second (about 67 gallons a minute) below the outcrop. In other words, at this very low stage of the stream almost all the water was passing through the limestone. The Creek was also measured at the bridge at Howes Cave, where it was found to have a flow of 6.5 cubic feet per second, or about 2,900 gallons a minute. By measuring and estimating the flow of the tributaries which enter between Barnerville and Howes Cave, it was determined that the water lost through the limestone at Barnerville is returned to the stream through the gravel in the stream bed at some point before Howes Cave, and is thus apparently not added to the ground water supply. Additional evidence in support of this is the chemical analysis from well So 247 (table 4) ending in the Coeymans limestone which was drilled as a test well by Hall and Company for the town of Cobleskill. The high concentration of minerals in the water from the Coeymans in this well suggests that there is no rapid circulation of the ground water in this part of the limestone, and that less concentrated water is not being added at the outcrop.

In the Schoharie Valley, although the outcrop of the Coeymans limestone is much more narrow than in the area north of Cobleskill Creek, exposures of this limestone very generally have enlarged joint cracks and sink holes. A number of sinks are reported south of Lasell Park in the village of Schoharie, and Becker's Cave in the Manlius limestone below Lasell Park may represent the former outlet of some of them. Ball's Cave, on the north slope of Barton Hill near the county line north of Schoharie, is entered through one of many sinks which have developed along joints trending approximately N 63° W. This cave has been well described by Grabau,[37] who includes cross sections and a ground plan, and was not entered during the present investigation. It is believed that this cave and its associated sinks may act as the collecting ground for the water which emerges from the springs which form the public water supply of Schoharie. Although spring So 44 Sp (table 3) which is the most likely outlet for any water absorbed by these sinks, is located among glacial boulders, it probably has its source in one of the limestones. Spring So 45 Sp emerges at the contact of the Manlius and Coeymans limestones some distance to the west of the sinks at Ball's Cave. It seems unlikely that these sinks could be the source for the spring unless they developed along the north-east trending joints. This, however, is not typical of sinks observed elsewhere in the County.

As has been indicated in the preceding paragraphs, all the caves in the Manlius and Coeymans limestones are noticeably controlled by the joints and bedding planes of the rocks. J. Harlan Bretz[38] in his exhaustive study of the processes of formation of limestone caves has concluded that the majority represent at least two cycles of erosional history, the initial development being below the water table, and subsequent modifications being due to free-surface streams flowing above the water table. Most of the caves in Schoharie County are more illustrative of the features of erosion by free surface streams than they are of solution in the zone of saturation, and as has been indicated, most of them contain streams which are actively at work enlarging the caves at the present time. Perhaps the most suggestive of phreatic solution is Ball's Cave, as described by Grabau, which contains at least two lakes and apparently does not possess a stream-graded floor. In both Howe Caverns and Secret Caverns, the free surface streams which are now flowing along the floors in graded courses have apparently carved a considerable part of the narrow, slot-like caves. In Howe Caverns, the Winding Way apparently represents a tributary to the main stream and appears to be typically stream-developed.

Wells penetrating the Coeymans and Manlius limestones might be expected to have a large yield where large cavities are intersected, and relatively low yields where the joints have not been greatly enlarged by solution. Records of yield of only 10 wells are available, and these wells indicate an average yield of only a little over 5 gallons a minute, two of the wells yielding 11 and 12 gallons a minute and two yielding less than a gallon a minute. The

[37] Grabau, A. W., Geology and paleontology of the Schoharie Valley: op. cit., pp. 348-351.
[38] Bretz, J. Harlan, Vadose and phreatic features of limestone caverns: Jour. Geology, vol. 50, p. 675, 1942.

average depth of 26 wells penetrating these limestones is 176 feet. In the limestone plateau area north of Cobleskill Creek and south of Carlisle Center and Grovernor Corners, the depth to water in wells is frequently over 100 feet, but this factor depends upon the completeness of drainage of the limestones, and in some wells in the same areas the water is not more than 7 feet below the surface.

New Scotland limestone and Becraft limestone

Hydrologically, the New Scotland limestone appears to act like the Rondout in that, in some places, it transmits water from overlying to underlying beds, and in some places its clayey character prevents the transmission of water and causes springs. The cave in the Becraft limestone on the farm of Mr. Charles J. Laplant, formerly the property of Sam Clark, on Dann's Hill west of Schoharie, is a spring in wet weather and issues from the Becraft at its contact with the shaly beds of the New Scotland. Although the Becraft is not an important source of water, it behaves like the Coeymans in that sinks are developed in it which transmit water to the underlying formations. The small sink 1½ miles southeast of Little York, at the bend in the road, which is shown on the topographic map as containing a pond, is developed along joints in the Becraft limestone. In an area southwest of Carlisle Center, the Becraft is exposed at and near the surface on the farm of Cora Snyder and adjacent farms, and in these fields the joints in the limestone are greatly enlarged so that underground drainage of a small stream has developed along the bedding planes. It is believed locally that both of these sinks connect with the springs on the Shaw farm. An effort was made to prove this during field work in the summer of 1946, but because of a drought at the time not enough water was passing into the sinks to carry a tracer. Miss Goldring[39] has reported a sink in the Becraft 2¼ miles northeast of Gallupville, the outlet of which is not known.

No wells ending in the Becraft have been reported, most of them passing through it into the New Scotland. Only about 6 records of wells that end in the New Scotland limestone are available, and it is probable that most of these also draw water from the overlying Becraft limestone. However, for both limestones together, the average yield of these wells is a little over 5 gallons a minute, and the average depth is about 173 feet.

Oriskany sandstone

Hydrologically, the Oriskany sandstone is of little importance because of its thinness, and there are no records of wells ending in it. The presence of limy cement, except where weathered, reduces the pore space that might otherwise contain water.

Esopus siltstone and Carlisle Center formation

There are only six wells recorded which are believed to end in and obtain most of their water from the Esopus siltstone. Four of these have an average yield of 8 gallons a minute. The average depth for five of the wells is 190 feet. The sixth well, well So 336, has a depth of 415 feet and a yield of 185 gallons a minute. The depth of this well indicates that it probably penetrates at least 100 feet below the Esopus, and as it is not cased in the bedrock it probably draws water from lower formations. The water is too highly mineralized to be used for anything but cooling purposes. The apparently greater yield of wells in the Esopus siltstone in contrast to wells in the underlying limestone is believed due to its extensively jointed character. As this siltstone itself is fine-grained and well cemented, the water must be contained in the numerous fractures which are characteristic of the rock.

As the Carlisle Center formation has not been recognized in well logs, there are no records of wells obtaining water from this formation. However, on the basis of its lithologic characteristics, its water-bearing properties are believed to be much like those of the Esopus siltstone, with the difference that the Carlisle Center, being coarser grained and not as well cemented, probably contains water in pore spaces as well as along joints and bedding planes, and possibly would yield more water to wells. The presence of the mineral glauconite above and below the formation would suggest that the water percolating from the overlying Onondaga limestone might be softened in the underlying beds, but this does not seem to be the case, as indicated by the chemical analyses of water from wells in the Esopus (table 4).

[39] Goldring, Winifred, Geology of the Berne Quadrangle; op. cit., pp. 118-119, 1935.

Onondaga limestone

Like the other massive limestones in Schoharie County, the Onondaga contains most of its water in joints and bedding planes which have been enlarged by solution. However, where the limestone is exposed at the surface, the effects of solution are not as conspicuous as in the lower limestones. Goldring[40] has reported sink holes and underground drainage in the Onondaga in Albany County in the Thompson's Lake—Indian Ladder area, but in Schoharie County such features are not common. No large sinks in the Onondaga are known in this area. On the outcrops, the joints are usually enlarged by solution. Springs appear to be fairly common in the Onondaga, though usually they have only small yield. On Dann's Hill, above the farm of Mr. Charles Laplant, a small spring issues from the Onondaga at its contact with the Esopus siltstone, and the joints are much enlarged in the limestone outcrop above the spring. About 3 miles southwest of Schoharie, where New York Route 145 crosses a tributary of Schoharie Creek, about 60 feet of Onondaga is exposed in the creek bed. At this locality there is a cave in the limestone which has been developed along a bedding plane, and from which it is believed water flows in wet weather. About 5 feet below the cave, a line of small springs emerges along a bedding plane, with a total flow in low water of perhaps 15 gallons a minute. In the Masick quarry, about 2½ miles south of Schoharie, a small spring So 55Sp issues along a joint crack, with a flow of about 4 gallons a minute. This spring, which is used in the quarry, is associated with deposits of crystalline calcite along the joint plane. About three-quarters of a mile west of Cobleskill, the Spring Water Ice Company obtains water from a flooded quarry in the Onondaga limestone, the water entering through a fissure reported to be about 6 inches wide. This spring, So 11Sp, is reported to have a yield of 100 gallons a minute. The flow is fairly steady, but it is necessary to return the condenser water to the quarry, otherwise the spring would be pumped dry.

There are records of yield for only four wells ending in the Onondaga limestone, one well yielding only half a gallon a minute, and the other three yielding 12, 29 and 30 gallons a minute. These figures give an average yield of nearly 18 gallons a minute, although too few wells are represented to make this figure very significant. It should also be noted that most of the wells listed as ending in the Esopus siltstone passed through the Onondaga, apparently without encountering any large supplies of water. The Onondaga, like the other massive limestones in Schoharie County, contains water along joint cracks and bedding planes, and the success of a well depends on the number and size of the cracks which it intersects. However, the relatively large yields of the three wells mentioned above, together with the numerous small springs in this limestone, suggest that the Onondaga is a better aquifer than any of the lower limestones. The average depth of 10 wells ending in the Onondaga is 135 feet.

Hamilton formation and Gilboa formation

In the Hamilton formation, including the Marcellus shale, and in the Gilboa formation ground water is contained in joint cracks and along the bedding planes, and possibly also in original pore spaces in some of the coarser sandstones. The average yield of 10 wells in the Marcellus shale is 10 gallons a minute. The average depth of these wells is 187 feet. The average yield of 30 wells in the Hamilton and Gilboa formations is 13 gallons a minute, and the average depth of 43 wells is 141 feet. The greater depth and slightly lower yield of wells in the Marcellus shale is to be expected because of the lower permeability of the shale. It is probable that much of the water in the Hamilton and Gilboa formations percolates from the siltstone beds, which are usually well jointed and thin-bedded. There are numerous small springs in the area underlain by these formations, many of which emerge at the contact of the siltstone with the shale beds (see table 3). A considerable part of the private supplies in the upland plateau area of the County are obtained from these small springs.

Onteora formation

Ground water occurs in the Onteora under much the same conditions as in the Gilboa formation and Hamilton formation, that is, largely in joints and bedding planes in the rock, although a small amount may occur in pore spaces in some of the coarser and less indurated sandstones. The average yield of 10 drilled wells in the Onteora is 14 gallons a minute, the yields ranging from 3½ to 30 gallons a minute. The average depth of 15 wells is 144 feet.

[40] Goldring, Winifred, Geology of the Berne quadrangle: op. cit., p. 143.

As in the part of the County underlain by the Hamilton and Gilboa formations, there are many small springs which are used for water supply on farms, with most of the springs recorded as issuing from bedrock along and above shale beds. West Conesville and Jefferson both obtain public water supplies from springs issuing from the Onteora formation.

Glacial and alluvial deposits

Because of the complexity of the glacial deposits, the occurrence of ground water in unconsolidated deposits is discussed here by principal areas of deposition. These areas are the Schoharie Valley, the Cobleskill Valley, the West Creek area, the Fox Creek valley, the Catskill-Little Schoharie Valley, the Manorkill Valley, the Broome Center area, the Jefferson area, and the Charlotte River Valley.

Schoharie Valley region.—The southern part of the Schoharie Valley, from the county line to the town of Gilboa, is now occupied by the Schoharie reservoir, a part of the water-supply system of New York City, and the glacial deposits in this area are largely covered by the reservoir. Borings made by the New York City Board of Water Supply at Gilboa show that Schoharie Creek, which is flowing on bedrock at this locality, formerly occupied a channel about 50 feet lower than its present one and about 130 feet below the land surface to the west (figure 4). This channel is filled with glacial drift, some of which appears to be till, especially in the lower parts of the buried valley, and some of which appears to be lake clay inter-stratified with sand and gravel. It is of interest that both blue and red clays are represented, indicating different sources for the material. The individual beds are lenslike and cannot be correlated from boring to boring. On either side of the present channel of Schoharie Creek, from Gilboa to North Blenheim, there are terraces composed of both bedrock and glacial drift, at elevations of 1,100 to 1,300 feet. Rich[41] has described sections of this terrace above the present level of the creek which, like the borings for the Gilboa dam, show an interbedding of till and stratified drift. The upper surface of the terrace is in most places veneered with lake clay. The remnants of the rock bench suggest that the Schoharie reached base-level and began to widen its valley at this elevation, and that subsequent uplift resulted in its cutting the deep, narrow, inner valley before the advance of the ice. The thick deposit of glacial material choking the valley forced the stream from its previous course so that it is now superimposed across the bedrock at Gilboa. The heterogeneous character of the glacial deposits may be due to several retreats and readvances of the ice, or to deposition on either side of a tongue of stagnant ice which filled the valley, and which was flanked at several different periods by long, narrow lakes. The high percentage of lake clay and till in the terrace deposits makes this area generally unfavorable for large supplies of ground water.

From North Blenheim to Breakabeen there is little information available as to the character of the glacial deposits. For about 1½ miles north of North Blenheim the valley is very narrow, and bedrock is exposed in the hill slopes. The preglacial channel is evidently also narrow and must lie nearly beneath the present channel of Schoharie Creek, as is indicated by the well records. There are traces of a terrace composed, like the Gilboa terrace, of both bedrock and drift, but as it is at an elevation of only about 900 feet it probably does not correlate with the one further south. About one mile south of Breakabeen on the east side of the Creek, about 15 feet of grey clay capped by about 2 feet of red clay is exposed in a road cut. It is believed that the glacial material in this part of the valley is similar to that farther south in containing a high percentage of clay, and is therefore not likely to yield large supplies of ground water. The only drilled wells in this area pass through the glacial drift and obtain water from the bedrock.

At Breakabeen, the Keyser Kill drops 200 feet in less than a mile to enter the Schoharie Valley, being in a hanging relationship with respect to the main valley. The bedrock at Breakabeen is between 20 and 25 feet below the land surface and most of the material in the valley of the Keyser Kill and on the high valley extending north of the Keyser Kill appears to be till. North of Breakabeen the Schoharie Valley widens, but where U. S. Route 30 crosses Schoharie Creek the creek is flowing on bedrock, showing that the preglacial channel must be between this locality and the east wall of the valley, a distance of less than half a mile. A well just south of this exposure of bedrock penetrated soil, gravel, and clay, reaching 18 feet of sand at a depth of 40 feet, and ending in this sand without reaching bedrock. About

[41] Rich, John L., Physiography and glacial geology of the northern Catskill Mountains: Am. Jour. Sci., 4th ser., vol. 39, pp. 137-166, 1915.

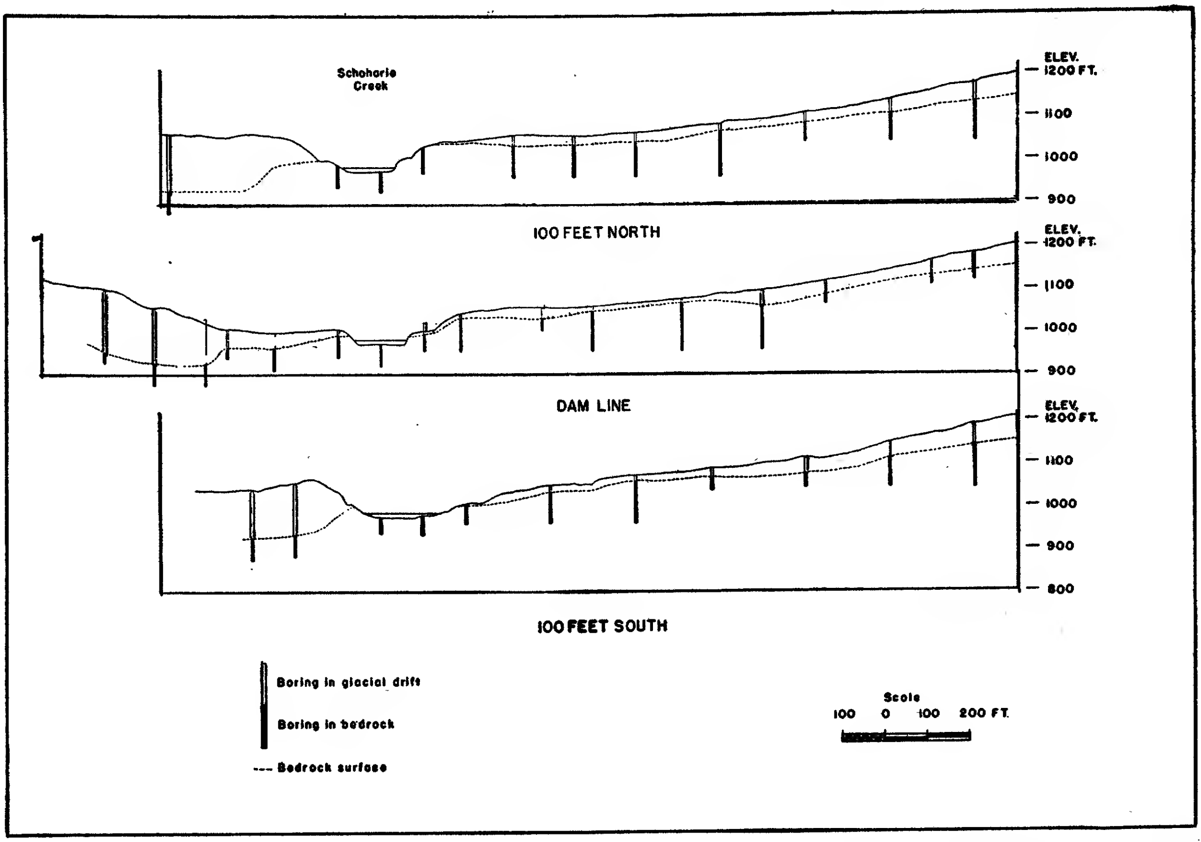

Figure 4.—Profiles of bedrock surface showing filled preglacial valley at Gilboa, from borings and profiles made by the New York City Board of Water Supply for the dam across Schoharie Creek.

one mile north of Breakabeen, Panther Creek enters the Schoharie Valley through a bedrock gorge in which is located Bouck's Falls, which, like Manorkill Falls, appears to be the result of the stream being left hanging above the main valley due to deepening of the latter by glacial erosion. Horizontal glacial groovings and striations on a vertical face of shale and siltstone indicate that in the early stages of glaciation the ice moved down the valley abrading the walls and floor. South of the present course of Panther Creek, aerial photographs show what appears to be an alluvial fan or delta previously built by the creek and abandoned. There are no records of wells or exposures on this land form to show whether or not it is composed of stratified sand and gravel, and the material exposed on the north bank of Panther Creek appears to be till. If this is an alluvial fan, wells situated on it might be expected to have fairly good yields, unless it is too well drained by Panther and Schoharie Creeks.

From Bouck's Falls to Fultonham and Middleburg, the floor of the Schoharie Valley becomes progressively wider and flatter and is believed to represent the bed of a glacial lake. Most of the material deposited in this lake appears to have been clay, but a well at Fultonham ends in gravel at a depth of 80 feet, although this well may be located on an alluvial fan or a delta formed at the mouth of the creek entering the valley at Fultonham. There are six driven wells between Fultonham and Middleburg, four of which are reported to end in gravel, and although the method of construction of driven wells precludes an exact knowledge of the material passed through, the fact that these small diameter wells yield enough water for domestic and farm uses indicates the presence of a permeable zone at less than 20 feet. This zone may be related to a former channel of Schoharie Creek, which is shown on aerial photographs, or to the position of most of these wells near the sides of the valley where coarser material may have been deposited. Most of the drilled wells in this part of the valley pass through the glacial deposits and obtain water from the bedrock. There is, however,

evidence of coarser, more permeable material on the east side of the valley just south of Middleburg, where Little Schoharie and Stony Creeks join Schoharie Creek.

From Middleburg to Schoharie the valley walls open out but the valley flat itself narrows at Davis Crossing, where a bedrock terrace veneered with till and stratified drift extends into the valley. Just south of Davis Crossing the record of well So 321 indicates that the preglacial channel is over 145 feet deep, and must lie nearly beneath the present stream bed. The valley floor widens from Davis Crossing to Schoharie, and is probably a part of the same lake bed forming the valley flat from Middleburg to Breakabeen. The records of wells So 336 at Middleburg, So 321 south of Davis Crossing, and So 285 at Schoharie show that most of the sediment in the valley consists of lake clays, with a few interbedded sands and gravels. Well So 336 passed through water-bearing gravel at 12 feet, possibly the same gravel horizon reported farther south in the valley, and entered bedrock at 90 feet. Well So 321 is reported as passing through 140 feet of clay and 5 feet of gravel, in which it ended. Well So 285 is reported as passing through blue clay, "hardpan," and quicksand before reaching a 5-foot gravel bed at 200 feet. Five other water-bearing-zones were encountered, one at 85 feet, before the lowest was reached. This well yielded 150 gallons of water a minute, but the quality was so poor that it could only be used for cooling. The records of these wells indicate that fairly large supplies of ground water may be obtained from the gravels at depth in this part of the Schoharie Valley, but the presence of the thick overlying blanket of clay, which would inhibit recharge, makes it unlikely that any large permanent industrial supplies could be obtained in this area.

From Schoharie north to Central Bridge and Esperance the valley flat narrows, and the hills on either side are thickly mantled with till. There are few records showing the character of the valley sediments in this area. At Central Bridge, well So 230 is reported as penetrating 181 feet of "hardpan" and clay, and flows at the surface, probably obtaining its water from a gravel bed. In the vicinity of Esperance, hills of till occur beside the creek, and at Esperance most of the drilled wells tap bedrock. It is probably in this area that the mass of ice or drift, which dammed the lake or lakes in the Schoharie Valley, was situated. Well So 84 at Esperance, which enters bedrock at 104 feet, indicates the location of the preglacial Schoharie channel. From Esperance to the county line Schoharie Creek flows through a narrow valley in till, and it is believed that its preglacial channel lies to the east of its present course, as at Burtonsville, just over the county line, where the creek was diverted and now flows through a gorge cut in bedrock[42].

Cobleskill Valley region.—The valley of Cobleskill Creek resembles the Schoharie Valley in possessing a preglacial channel which is over 100 feet below the present stream bed. However, unlike the Schoharie Valley, it lacks a valley flat with the exception of a small area near Warnerville, and most of the surficial glacial deposits appear to be in the form of till. The glacial history of this valley is complex, and the presence of thick clay beds reported in well logs suggests that at one time it contained glacial lakes, which apparently existed before the formation of the drumlins which now occupy the valley. If this is the case, at least one retreat and advance of the ice is indicated. The east-west direction of the valley and the high hills of Hamilton siltstones and shales which hindered the southward flow of the ice tended to localize thick deposits of till in the Cobleskill Valley.

The upper or western part of the valley trends southwest, and lies within the area of high hills of Hamilton rocks. This part of the valley between West Richmondville and Richmondville is narrow, and is characterized by hummocky topography which may be underlain by stratified drift. Unfortunately there are no exposures or well logs in this area which provide information on this point. From Richmondville to Warnerville the valley is wider and is relatively flat. A test well at the junction of West and Cobleskill Creeks, which was drilled by Hall and Company for the village of Cobleskill, showed that this flat area is underlain largely by clay with some fine sand above the bedrock. From Warnerville to Cobleskill the valley flat narrows, but the logs of three other test wells drilled by Hall and Company indicate that this area is also underlain by clay interbedded with fine sand. Some of the material described in these logs (see table 5) as "clay and gravel hardpan" may be till, but the greater part of the clay is probably lake deposited.

[42] Berkey, C. P., The Burtonsville site on the Schoharie: one of a series of reconnaissance memoranda relating to certain prospective dam sites and aqueduct locations prepared for New York City Board of Water Supply, 1921-1924. Unpublished, in files of New York City Board of Water Supply.

From Cobleskill to Howes Cave, the valley contains a number of drumlins, some of which are cut through by Cobleskill Creek. At Barnersville and for about three-quarters of a mile west of Barnersville, the creek is now flowing over an outcrop of the Coeymans limestone on which these drumlins lie. As the well logs at Cobleskill and between Cobleskill and Warnerville show a maximum depth to bedrock of 130 feet, it would appear that in the Barnersville area the stream has been diverted from its former channel, either by a lobe of ice pushing through the low part of the limestone plateau immediately to the north, or by an accumulation of drift. The original channel probably lies north of the existing stream bed, but there are no well logs in this area by which it can be located. From Howes Cave east to the junction of Cobleskill with Schoharie Creek the valley widens slightly, and just east of Howes Cave there is a terrace underlain by blue and brown lake clay about 40 feet above the present stream bed. This clay is at a higher elevation than the clay in the Schoharie Valley, and the lake in which it was laid down was probably not connected with the lake in the Schoharie Valley. Wells at Howes Cave pass through more than 100 feet of clay before reaching water-bearing gravel. The clay in this area may correlate with the clay encountered in wells near Cobleskill. The two wells ending in glacial drift at Howes Cave and the four test wells drilled by Hall and Company for the village of Cobleskill between Cobleskill and Warnerville, all flow at the land surface in amounts ranging from 2 to 35 gallons a minute. Several wells near Cobleskill which obtain water from the bedrock formations also flow, and it is believed that the water from the flowing wells in the glacial deposits has been derived from the bedrock formations. Because of the east-west direction of the Cobleskill Valley, roughly parallel to the strike of the bedrock formations, and the southward dip of these formations, water which is absorbed into the rock in the hills north of the valley is under artesian pressure when it has percolated into the rocks underlying the valley. The thick deposits of glacial clay in the valley act as a confining bed and prevent the upward escape of water unless penetrated by wells. There are no indications that the glacial gravels which contain water under artesian pressure crop out at higher levels on the valley sides.

The presence of thick deposits of clay throughout the Cobleskill Valley, and the failure of the test wells drilled for the village of Cobleskill to obtain the desired yield of 100 gallons of water a minute, indicate that although small supplies of water may be obtained from drilled wells in this area, conditions are not favorable for the development of large supplies.

West Creek area.—West Creek, which joins Cobleskill Creek at Warnerville, flows along the front of the northwestern extension of the "2,000-foot plateau". To the northeast the bedrock is covered by a considerable thickness of till, much of it in the form of drumlins, and to the southwest the higher Hamilton hills are covered by a thinner veneer of till, but there is evidence that the valley of West Creek itself and some of the tributary valleys may contain stratified drift. That this material may be similar to that in the Cobleskill Valley is indicated by the log of well So 119 (table 5) near Clove, about three-quarters of a mile west of Hyndsville, which passed through interbedded clay and fine sand to a depth of 191 feet, but apparently obtained most of its water from the bedrock. Well So 122 is reported as passing through 360 feet of glacial material and ending in "hardpan." This well appears to be situated on the side of a drumlin. Although these records show little possibility of obtaining large supplies of ground water, it is possible that north of Hyndsville, in the vicinity of Janesville, Seward, and Dorloo, coarser, more permeable material may occur in the stratified drift. Southwest of Lawyersville aerial photographs show a land form that appers to be an alluvial fan. There are no wells in this area, but if this fan is composed of well sorted sand and gravel and is below the water table, it may yield fairly large supplies of ground water.

Fox Creek Valley region.—The valley of Fox Creek, like that of Cobleskill Creek, contains a considerable amount of till, much of it in the form of drumlins. There are few records of drilled wells except near the mouth of the valley, but it is believed that conditions are in general similar to those in the Cobleskill Valley. That Fox Creek, like the other main streams in the County, originally possessed a deeper valley subsequently filled by glacial drift is indicated by the record of well So 284, which is near the present stream channel just east of the Schoharie Valley, and which passed though 148 feet of clay, with a zone of cobbles and gravel at 30 feet, without reaching bedrock. This well was abandoned because it did not yield enough water for farm purposes. Although some gravel lenses may occur in the till and clay in the Fox Creek valley it is probable that large supplies of water cannot be developed in this area.

Catskill-Little Schoharie Valley region.—The upper part of the valley of Catskill Creek in Schoharie County has been called the "Franklinton Channel" by Rich,[43] who believed that it represented the spillway for the waters of the glacial lake ponded in the Schoharie Valley. However, as may be seen on plate 1, drilled wells in this area end in glacial drift which is in places over 200 feet thick, a fact which argues against this being the outlet of a lake, as such outlets are usually floored by bedrock because the water leaving the lake has deposited its sediment and is eroding rather than aggrading its course. It is also of interest that the tributary to Little Schoharie Creek, which heads in the north end of this valley, is flowing on a much steeper course than that of Catskill Creek and is in the process of capturing the headwaters of the latter, although Catskill Creek has a much shorter course to the Hudson than has the Schoharie drainage, and in other areas has captured part of this drainage. It has been suggested by Professor R. F. Flint (personal communication) that these facts suggest the material in the Catskill Valley was deposited from a source, presumably a tongue of melting ice, situated in the north end of the valley, and the thickness of this material was such that it reversed the normal gradient of this part of the valley so that it drained into Catskill rather than Schoharie Creek. In this case the original divide between the Catskill and Schoharie drainages may be in the vicinity of Preston Hollow, in Albany County, and the bedrock valley underlying the glacial fill would become progressively deeper north of this point. The glacial drift filling the valley is shown by well logs to consist of clay, sand, and gravel, and some wells report "hardpan," which may also mean that till is present. If this material is till, it may either indicate readvance of the ice over the area, or slumping and landsliding of previously deposited till into the deep narrow valley. The different depths at which water-bearing gravels are encountered in closely adjacent wells, as at Livingstonville suggest that the material is in complexly interbedded lenses which are not continuous over any great distances. The presence of two flowing wells (So 394, So 462) indicates a local clay bed of sufficient extent to permit the accumulation of water under artesian pressure beneath it. None of the wells in this valley have been developed to yield large supplies of ground water, so the possibilities in this respect are not known. Adequate farm and domestic supplies appear to be generally obtainable. The most favorable area for larger supplies would seem to be at the present divide between the Catskill and Schoharie drainage or north of this divide, as in this area the valley is wider, and the materials deposited are nearer their source and therefore more likely to be coarse in texture. However, the large percentage of clay reported in well logs makes the development of such supplies doubtful.

Manorkill Valley region.—The valley from West Conesville to Manorkill is filled by a considerable thickness of stratified drift, much of it in the form of kames, terraces, eskers, and other forms commonly associated with stagnant ice. Rich[44] has described these forms in some detail on the supposition that they were deposited between two lobes of active ice. A gravel pit about three-quarters of a mile west of Conesville shows about 20 feet of moderately well stratified fine to coarse sand and gravel, pink in color. The pebbles in the gravel are mostly grey and red sandstone. At Conesville three wells 50, 132, and 180 feet deep end in gravel, and each one has a yield of 20 gallons of water a minute. Unfortunately none of these wells have logs, but one well is reported to pass through clay and hardpan as well as sand. From Conesville to Manorkill the drift thins, and east of Manorkill it disappears, the divides being scoured down to bedrock. The wide, open character of the Manorkill Valley, the thickness of fairly permeable stratified drift and the relatively large yields of the farm and domestic wells ending in it, indicate that this area might be expected to yield larger supplies of water to wells than other parts of the County. Although no wells in this area have been developed for large yields, it is possible that yields of 100 or more gallons a minute could be obtained, especially between West Conesville and Conesville.

Broome Center area.—In the area east of Broome Center and in the upper parts of the valleys of the Platter Kill and the Keyser Kill, there are deposits of stratified drift similar to those in the Manorkill Valley. East of Broome Center there are many kames and in the upper parts of the two valleys a number of deltas described by Rich.[45] Although there are no records of drilled wells ending in drift in this area, the type of material exposed in gravel pits is similar to that in the Manorkill Valley except that it is yellow in color, and it is probable that good supplies of ground water could be recovered.

[43] Rich, John L., Physiography and glacial geology of the northern Catskill Mountains: op. cit., p. 130.
[44] Rich, John L., Physiography and glacial geology of the northern Catskill Mountains: op. cit., pp. 105-107.
[45] Rich, John L., Physiography and glacial geology of the northern Catskill Mountains: op. cit., pp. 107-110.

Jefferson area.—On the west side of the Schoharie Valley, the area around Jefferson, on the divide between Middle Brook, Mine Kill, and Mill and West Creeks, is also characterized by kame and outwash deposits of stratified sand and gravel. As exposed in gravel pits these deposits consist of moderately well stratified sand and gravel, predominantly yellow in color, containing cobbles of red and grey sandstone and some of igneous and metamorphic rock from the Adirondacks. Most of the ground water supplies in this area are obtained from dug wells or springs, so no information is available on the thickness or possible yield of these deposits. However, it is believed from the character of the material that fairly good yields might be expected.

Charlotte River Valley region.—The part of the Charlotte River Valley which lies within Schoharie County is, like other main valleys in the County, filled to a depth of probably over 100 feet with glacial drift. However, the available information indicates that most of this is in the form of till or clay, and with one exception, well So 188 which is only 34 feet deep, all of the drilled wells in the valley for which records were obtained end in bedrock. Along the northwest side of the valley north of Charlottesville and in the valley south of Charlottesville, the surface topography suggests that some sand and gravels may be present in the form of kames, but no cuts were observed which would substantiate this. Until further evidence is obtained it is believed that large supplies of ground water are not to be expected from the glacial drift in this area.

The remaining parts of Schoharie County which have not been treated as separate areas are, with few exceptions, covered with a blanket of till, which yields adequate supplies for domestic purposes to dug wells, but from which large supplies cannot be obtained.

In conclusion, it is believed that the most favorable areas in Schoharie County for obtaining large supplies of ground water from the glacial deposits are the Manorkill Valley, the upper Catskill Valley, the Broome Center and Jefferson areas, and the Schoharie Valley, in that order.

RECOVERY

History

As was indicated in the introductory part of this report, Schoharie County has a greater percentage of the population engaged in agricultural occupations than any other county in New York State, and of the 2,453 farms reported in the County in the 1940 census, the water needs of the vast majority are supplied by wells and springs and ground water. Of the approximately 800 records of water supplies obtained in the course of this investigation, nearly two thirds are of dug wells and springs, and approximately one third are of drilled wells. Driven wells are uncommon, probably because of the prevalence of clay in the glacial drift, and only about a dozen have been reported. These are probably not all of the driven wells in the County, however, as no attempt was made to obtain a complete inventory of wells of any type or even of representative groups of all types.

Records of water supplies in Schoharie County obtained by the Geological Survey in 1902 indicate that at that time nearly all of the farms were supplied by springs and dug wells, drilled wells being relatively uncommon. The increase in drilled wells in the last 40 years and the development of the electric pump made possible increased consumption of water for sanitary and other purposes on farms.

Types of wells

Drilled wells.—These average 6 inches in diameter and are generally cased to bedrock. All of the wells for which records are available were drilled by the cable tool method, and there are no records of gravel packed wells ending in glacial drift. The yields of 30 drilled wells ending in sand or gravel average approximately 16 gallons a minute, and it is probable that larger yields might be obtained with more intensive development. Well So 285 is reported to yield 150 gallons a minute, and well So 381 is reported to flow 160 gallons a minute (table 6). The latter well was not included in the averages because of its exceptional nature. The average depth of drilled wells ending in sand and gravel is approximately 114 feet. Well So 188 and well So 463 are 34 feet deep and were the shallowest sand and gravel wells located during the investigations.

The yields of 107 drilled wells ending in bedrock average 7.25 gallons a minute. Well So 336 with a depth of 415 feet is reported to yield 185 gallons per minute. This well, because of its large yield, was not included in the averages. The average depth of drilled wells ending in bedrock is approximately 181 feet. The shallowest well (So 599) at the Stamford Country Club, is 42 feet deep with a reported yield of 30 gallons a minute. The deepest well (So 213), now abandoned, has a depth of 700 feet.

Driven wells.—The majority of driven wells are 1¾ inches in diameter and have an average depth of 19 feet. They all tap glacial material and yield sufficient quantities of water for domestic and farm use. Water levels in these wells range between 2 and 22 feet below the land surface. Most of the driven wells in Schoharie County are located in the northern part of the Schoharie Valley region in the area around Fultonham and Middleburg.

Dug wells.—The dug wells average about 3 feet in diameter, are generally cased with stone, and are furnished with either a pitcher pump or buckets, although some have electric or gasoline pumps. Dug wells in the County generally supply sufficient water for domestic and most farm purposes, averaging several gallons a minute.

Most of the dug wells in the County obtain water from glacial deposits, primarily from glacial till. The only dug well known to obtain water in alluvium is well So 651. It is 14 feet deep and 3 feet in diameter, and is located on the bank of Fox Creek, and owned by the Village of Schoharie. This well yields about 60,000 gallons of water a day, or more than 40 gallons a minute, with only a small drawdown. It is believed that this well acts as an infiltration gallery and draws water from Fox Creek, and that its capacity is limited only by the flow of that stream.

Springs.—Springs are common throughout the County, especially in the uplands, and most farms with dug wells also have one or more springs to provide water for stock. A number of springs issue from till, especially where water percolating downward encounters a zone containing more clay. Many small seeps of this type are visible in road and railway cuts, and in steep banks undercut by streams. Springs also occur along the contact between the limestone formations, which contain abundant joints enlarged by solution, and underlying less permeable shales. Small springs are common in the Hamilton and higher formations at the contact of siltstone with shale beds. The yields from most springs seem to be highly variable throughout the year, and accurate information on flow in most cases is not available. For these reasons no estimate of average yields has been made but a range exists from springs which are dry during summer months and have maximum flows of less than a gallon per minute to several springs known to have a dry-weather flow of approximately 20 gallons a minute (table 3).

Recovery of ground water from springs which are usually cased with stone, wood, or concrete, is generally accomplished by gravity flow. In some cases, the water from one or more springs may be collected in small reservoirs. It is then either pumped to its destination or piped by gravity flow.

UTILIZATION

Out of a total population of 20,812, approximately 4,100 people in Schoharie County are served by public water supplies derived from surface waters, and approximately 2,400 are served by public supplies derived from ground waters. The remaining population of about 14,300 depends, without exception as far as the writer is aware, wholly or in part on ground water for all domestic and farm needs. Use of ground water for industrial and commercial purposes is very limited in Schoharie County. It is estimated that consumption of ground water in the County for all uses totals about two million gallons daily.

Private supplies

Assuming that the average per capita consumption from private supplies for domestic use is 50 gallons a day,[46] it is estimated that the total pumpage in Schoharie County from wells and springs for such uses is over three quarters of a million gallons a day. It seems probable that the consumption by farm animals would raise the total ground-water consumption from private supplies to more than a million gallons daily.

[46] Rural water-supply sanitation, recommendations of the Joint Committee on rural sanitation: Federal Security Agency, U. S. Public Health Service, Public Health Reports, Supp. 185, 1945.

Table 3.—Records of selected springs in Schoharie County, New York.

Spring number	Location[a]	Owner	Altitude above sea level (feet)[b]	Topography	Geologic subdivision[c]	Yield (gallons per minute)	Temperature (°F.)	Use[d]	Remarks
So 1Sp	10V, 5.1N, 7.7W	M. Foland	1,120	Hillside	Cobleskill limestone	..	..	Farm	
So 2Sp	10V, 4.8N, 7.3W	A. Eldridge	1,160	Hillside	Cobleskill limestone	..	..	Farm	
So 3Sp	10V, 8.9N, 5.5W	D. Green	900	Hillside	Cobleskill limestone	..	..	Farm	
So 5Sp	10V, 8.5N, 6.1W	White Sulfur Company	1,100	Hillside	....	150	..	Med	Magnesia spring, developed and commercialized.
So 6Sp	10V, 8.3N, 6.1W	White Sulfur Company	1,100	Hillside	Cobleskill dolomite	200	40	Med	Sulfur spring, developed and commercialized. Contains hydrogen sulfide.
So 8Sp	11V, 11.7N, 6.8W	Mike Kodra	1,280	Hillside	Hamilton group	..	..	Dom	
So 11Sp	11V, 6.6N, 0.1W	Cobleskill Spring Water Ice Company	960	Valley	Onondaga limestone	100	..	Com	Flooded quarry. Used for making ice.
So 16Sp	11V, 3.4N, 1.2W	E. Betts	1,620	Hillside	Hamilton group	8	50	Farm	
So 18Sp	11V, 8.9N, 4.4W	G. Butler	1,350	Hillside	Pleistocene gravel	..	..	Farm	
So 19Sp	11V, 8.8N, 4.7W	L. Joslyn	1,400	Hillside	Pleistocene clay	8	50	Farm	
So 20Sp	11V, 9.0N, 5.6W	A. Butler	1,450	Hillside	Pleistocene clay	..	60	Dom	Dry at times.
So 23Sp	11V, 8.4N, 3.8W	F. Danley	1,400	Hillside	Hamilton group	4	..	Dom	Dry for a few weeks each year.
So 24Sp	11V, 8.1N, 2.1W	C. Johns	1,300	Valley	Pleistocene gravel	..	50	Farm	Reported never to be dry.
So 26Sp	10V, 10.3S, 0.6W	L. Jones	1,877	Hillside	Pleistocene gravel	4	..	Farm	Spring cased with stone. Gravity flow to house and barn.
So 27Sp	10V, 12.4S, 1.5W	B. Mangan	1,651	Hillside	....	..	..	Farm	Spring improved with concrete reservoir.
So 28Sp	11V, 5.0N, 8.4W	J. Koker, Jr.	1,880	Hillside	Pleistocene till	10	54	Dom	
So 36Sp	11V, 0.4N, 3.8W	H. B. Ruland	1,550	Hillside	....	..	60	Farm	Reported never to be dry.
So 41Sp	10V, 7.4S, 8.2W	....	790	Hillside	Cobleskill dolomite	25	..	Dom	Fluctuates with the lake in Howes Cave and reported to be the outlet.
So 43Sp	10V, 3.8S, 7.6E	J. Livingston	765	Valley	Onondaga limestone	..	..	Farm	
So 44Sp	10V, 4.3S, 12.1E	Village of Schoharie	920	Hillside	Pleistocene till	25	..	PWS	Concrete collecting basin. Yield based on low flow.[e]
So 45Sp	10V, 4.8S, 10.9E	Village of Schoharie	800	Hillside	Manlius, Rondout ls.	25	..	PWS	Fluctuation large. Yield based on low flow. Reported in the spring to fill a cave 36 square feet in size.[e]
So 49Sp	10V, 5.5S, 2.5E	E. R. Tellapaugh	1,050	Hillside	....	3	..	Dom	Mineral spring. Reported to contain hydrogen sulfide. Low in dry weather.[e]
So 50Sp	10V, 7.4S, 3.2E	A. Waltz	1,880	Hillside	Hamilton group	..	45	Farm	Never dry. Spring improved with wood reservoir.
So 52Sp	10V, 6.8S, 5.2E	H. McCoy	1,190	Hillside	Pleistocene clay	..	50	Farm	
So 55Sp	10V, 3.6S, 9.1E	William Masick	770	Hillside	....	4	..	Dom	Used at a quarry.
So 56Sp	10V, 9.7S, 5.6E	G. Mickle	1,110	Hillside	Pleistocene gravel	5	42	Farm	
So 58Sp	10V, 11.3S, 9.1E	M. Bevins	717	Hillside	Hamilton group	4	..	Farm	
So 60Sp	10V, 12.3S, 7.5E	P. J. Mettice	700	Hillside	Hamilton group	10	..	Farm	

See footnotes at end of table.

Table 3.—Records of selected springs in Schoharie County, New York. (Concluded)

Spring number	Location[a]	Owner	Altitude above sea level (feet)[b]	Topography	Geologic subdivision[c]	Yield (gallons per minute)	Temperature (°F.)	Use[d]	Remarks
So 64Sp	10V, 12.8S, 6.4E	F. C. Barber	1,000	Hillside	Pleistocene gravel	..	45	Dom	
So 68Sp	10V, 13.8S, 9.8E	R. H. Bauers	940	Hillside	Pleistocene boulders	5	48	Farm	
So 71Sp	10V, 16.8S, 6.2E	W. D. Campbell	1,250	Hillside	Pleistocene till	..	46	..	Reported never to be dry.
So 72Sp	10V, 15.1S, 4.0E	H. Mattice	1,020	Hillside	Hamilton group	8	50	Farm	
So 74Sp	10W, 3.5S, 1.0E	C. Cook	1,275	Hillside	New Scotland limestone	15	49	Farm	Reported to be dependable for the last 100 years.
So 76Sp	11V, 2.3S, 1.7E	D. Vermon	940	Hillside	Hamilton group	5	50	Farm	
So 80Sp	11V, 1.4S, 7.7E	G. Duncan	1,600	Hillside	Pleistocene clay	8	42	Dom	Reported to be never dry.
So 82Sp	11V, 3.1S, 6.5E	G. W. Bailey	2,000	Hillside	Onteora formation	..	40	Dom	Reported to be never dry.
So 89Sp	11V, 4.7S, 5.5E	V. Buell	1,720	Hillside	Onteora formation	5	55	Dom	Dry at times.
So 91Sp	11V, 4.3S, 6.0E	M. Hubbard	1,760	Hillside	Onteora formation	..	54	Farm	Never dry.
So 92Sp	11V, 4.4S, 7.0E	E. Hubbard	2,012	Valley flat	Pleistocene gravel	8	52	Farm	Never dry.
So 96Sp	11V, 4.9S, 3.9E	A. Kingsley	1,800	Hillside	Pleistocene gravel	..	55	Dom	Never dry.
So 103Sp	11V, 7.9S, 1.8E	W. Snyder	1,420	Hillside	Pleistocene gravel	8	50	Farm	Never dry.
So 105Sp	11V, 7.9S, 1.3E	R. G. Merwin	1,400	Hillside	Pleistocene till	..	48	Farm	Never dry.
So 109Sp	11V, 8.1S, 4.2E	Village of West Conesville	1,460	Hillside	....	..	..	PWS	Never dry.
So 112Sp	11V, 8.8S, 4.7E	D. J. Hughes	1,820	Hillside	Onteora formation	8	50	Dom	Dry at times.
So 114Sp	11V, 7.8S, 7.0E	L. Tuttle	1,896	Hillside	Pleistocene gravel	10	48	Farm	Never dry.
So 124Sp	11V, 0.7S, 0.7W	J. Rother	1,280	Valley	Pleistocene clay	8	50	Dom	Never dry.
So 135Sp	11V, 0.7S, 6.3W	F. Mower	1,860	Hillside	Gilboa formation	..	45	Farm	Never dry.
So 139Sp	11V, 2.0S, 4.5W	Village of Jefferson	2,300	Hillside	....	..	..	PWS	Never dry.
So 141Sp	11V, 2.2S, 3.9W	J. Beggs	2,000	Hillside	Gilboa formation	..	61	Farm	Never dry.
So 146Sp	11V, 3.9S, 2.5W	F. L. Cornell	1,591	Hillside	Gilboa formation	11	46	Farm	Never dry.
So 154Sp	11V, 5.8S, 2.1W	L. Foote	1,940	Hillside	Onteora formation	4	50	Farm	Never dry.
So 155Sp	11V, 6.4S, 3.0W	A. Soffer	1,780	Hillside	Pleistocene till	..	45	Farm	Dry at times.
So 156Sp	11V, 4.6S, 5.8W	J. Cahill	2,000	Hillside	Onteora formation	4	58	Farm	Never dry.

[a] The location of So 1Sp is 5.1 miles north and 7.7 miles west of the intersection of lines 10 and V. For explanation of symbols see section, "Introduction, methods of investigation".
[b] Approximate altitude from topographic map.
[c] ls., limestones.
[d] Med, medicinal; Dom, domestic; Com, commercial; PWS, public water supply.
[e] For chemical analyses see table 4.

Public supplies

Of the eight public water supplies in Schoharie County, six are supplied wholly or in part by ground water. However, the consumption from surface water sources is about 800,000 gallons a day whereas ground water pumpage is only about one-half million gallons a day.

Cobleskill, the largest town in the County (population 2,617), is one of the two supplied entirely by surface water. The present source of supply is a reservoir above the village of Mineral Springs, about 3 miles southeast of Cobleskill. This reservoir has a capacity of 10 million gallons, and the water reaches the village by gravity. The present consumption is reported as 650,000 gallons a day. The water is filtered and chlorinated. Recently the Town of Cobleskill sought to supplement its supply by wells, but the desired yield of 100 or more gallons a minute of water of good quality was not obtained by any of the test wells (So 247, So 248, So 649, and So 650).

Middleburg (population 1,074), the next largest town in the County, obtains its water from Little Schoharie Creek and Schoharie Creek. The water is passed through two sedimentation basins to a covered concrete reservoir with a capacity of 110,000 gallons, from which it flows to the town by gravity. The water is chlorinated. The daily consumption is about 120,000 gallons, of which 95 percent is used by the inhabitants of the town.

Schoharie (population 941), the county seat, is supplied by two springs (So 44Sp, So 45Sp) on the slopes of Bartons Hill, and by an auxiliary well (So 651) beside Fox Creek. The well is not pumped unless the water in the springs is very low, but it can supply up to 60,000 gallons a day. The water moves from the springs to a steel tank with a capacity of 350,000 gallons, and from the tank to the town by gravity flow. It is treated with hypochlorite. The maximum consumption is 150,000 gallons, and the average consumption about 100,000 gallons a day.

Sharon Springs, which had a population of 433 in the 1940 census, is a summer resort, and the population is reported to increase to over 3,500 during the summer months. The town is supplied from two ponds, a reservoir, and a deep well (So 640) which is used in summer. The water flows to a filter plant by gravity, and is then pumped to two tanks above the town. In addition to being filtered, the water is chlorinated, and the water from the deep well is softened. This deep well is reported to have been pumped two hours over a five hour period in 1934, with a drop in water level from 114 to 195 feet below land surface and a decrease in yield from 225 to 188 gallons a minute. The maximum water consumption is about 500,000 gallons a day and averages about 200,000 gallons per day.

The village of Richmondville (population 598) is supplied by springs which flow to a reservoir at West Richmondville which has a reported capacity of 48 million gallons. The water is distributed by gravity, and the treatment includes chlorination, carbon, soda ash, and alum, and passage through three settling basins. The maximum reported use is about 157,000 gallons a day, and averages about 95,000 gallons a day.

The village of Central Bridge (population 400) is supplied by a spring-fed artificial pond, which is reported to have a capacity of 21 million gallons. This reservoir, which is about 1½ miles west of the village, becomes about two-thirds empty during the summer and is supplemented by a similar, smaller pond. The water is distributed by gravity and is chlorinated. The maximum consumption is 110,000 gallons a day, and the average use is approximately 80,000 gallons per day. The public supply is utilized by the Delaware and Hudson Railroad, which uses about 1,100 gallons a day, and the Sheffield Farms creamery, which uses about 1,400 gallons daily. During a recent fire on the railroad, involving the burning of a number of oil tank cars, the Central Bridge Water Company supplied the railroad with 4 million gallons of water in two days.

West Conesville (population 125) is supplied from a spring (So 109Sp) at the foot of Stevens Mountain, and the average consumption is about 7,500 gallons a day. The water, which is not treated, flows by gravity to a concrete roofed reservoir from which it is likewise distributed by gravity.

The village of Jefferson (population 300) is supplied by a spring (So 139Sp), the water from which flows by gravity to a concrete reservoir with a capacity of 13,000 gallons.

The water is distributed by gravity, and is not treated, but is tested every two months. The maximum consumption is reported as being 60,000 gallons a day and the average consumption 40,000 gallons a day.

The remainder of the small unincorporated villages in the County do not have public water supplies. The only incorporated village which lacks a public water supply is Esperance (population 219), and it is understood that a public supply for this village is being considered.

Industrial supplies

The few industrial plants in Schoharie County are located in the larger towns such as Middleburg and Cobleskill, and use the public water supplies of these towns.

Commercial supplies

Three milk processing plants, in North Blenheim, Manorkill, and Seward, obtain water from wells So 444, So 532, and So 98, respectively, the records of which are given in table 6. The Borden plant at Middleburg has a well (So 336) which is used for cooling purposes only, all other water being obtained from the public supply.

QUALITY

Mineral constituents

"In general the mineral constituents of natural waters that determine their suitability for most purposes are the total dissolved solids or concentration, the total hardness, and the content of iron. Locally, the concentration of certain other constituents such as sodium chloride (common salt) may limit the usefulness of a water. Waters with less than 500 parts per million of total dissolved solids generally are entirely satisfactory for domestic use, except for difficulties resulting from their hardness or occasional excessive iron content. Waters with more than 1,000 parts per million are likely to contain enough of certain constituents to produce a noticeable taste or to make the water unsuitable in some other respects. However, some waters that contain more than 1,000 parts per million are satisfactory for domestic use and for some industrial uses, such as cooling.

"The hardness of a water is commonly recognized by the increased amount of soap needed to produce a lather, and by the curdy precipitate that forms before a permanent lather is obtained. The constituents that cause hardness (mainly calcium and magnesium) are also the active agents in the formation of scale in steam boilers and tea kettles. Water with a hardness of less than 50 parts per million is generally rated as soft, and treatment for the removal of hardness is rarely justified. Hardness between 50 and 150 parts per million does not seriously interfere with the use of water for most purposes, but it does slightly increase the consumption of soap, and its removal by a softening process is profitable for laundries and certain other industries. Treatment for the prevention of scale is necessary for the successful operation of steam boilers using waters in the upper part of this range of hardness. Hardness of more than 150 parts per million is readily noticeable and where the hardness is 200 or 300 parts per million it is common practice to soften water for household use.

"If a water contains much more than 0.1 part per million of iron, the excess may separate out after exposure to the air and settle as the reddish sediment common in many well waters. Iron stains cooking utensils and bathroom fixtures, and in certain industries may cause serious trouble owing to staining, as in the manufacture of paper, the rayon and tanning industries, and in laundries. Iron generally can be removed by simple aeration and filtration, or by the methods used in softening water."[47]

The above quotation, although taken from a report on ground water in Pennsylvania, is equally applicable to the quality of ground water in New York State. Chemical analyses (table 4) of 40 wells and springs in Schoharie County show only one well (So 247) in which the total solids are over 1,000 parts per million, but ten wells with total solids over 500 parts per million.

[47] Lohman, S. W., Ground-water resources of Pennsylvania: Pennsylvania Dept. Internal Affairs, Bull. W-7, pp. 24-25, 1941.

Table 4.—Chemical analyses of water from selected wells and springs in Schoharie County, New York.

(Analyses by New York State Department of Health unless indicated otherwise. Dissolved constituents given in parts per million.)

Well and spring number	Depth (feet)	Geologic subdivision[a]	Date of collection	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) + potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness (As $CaCO_3$) Total	Carbonate	Noncarbonate	pH
So 11	144	Rondout and Cobleskill limestones	10/22/46	812	..	7.8	0.5	..	..	..	455	1.8	9.0	..	..	360	360	0	7.1
So 14	92	Pleistocene deposits	10/22/46	769	..	.6	.4	..	..	..	106	373	43	..	..	285	87	198	7.7
So 20	300	Coeymans to Schenectady fms.	2/8/40	..	..	.03	.01	..	..	..	229	..	2.0	..	0.02	820	188	632	7.3
So 43	72	Onondaga limestone	10/22/46	250	..	.5	.01	..	..	..	284	48	.6	..	..	210	210	0	7.5
So 49	170	Schenectady formation	10/31/46	486	..	.8	.01	..	..	..	308	116	2.2	..	..	20	20	0	8.7
So 57	200	Schenectady formation	10/31/46	383	..	.05	.01	..	..	..	309	28	34	..	..	360	253	107	7.5
So 75	214	Schenectady formation	11/19/45	536	..	.6	.01	..	..	..	236	173	9.8	..	..	360	175	185	7.2
So 84	154	Schenectady formation	12/12/45	694	..	2.0	.4	..	..	..	533	2.2	145	..	..	320	320	0	7.5
So 95	260	Marcellus shale	10/31/46	328	..	2.5	.03	..	..	..	278	60	.8	..	..	210	210	0	7.6
So 98	86	Marcellus shale	10/28/46	682	..	4.5	.01	..	..	..	284	274	22	..	..	370	192	178	7.7
So 122	360	Pleistocene till	10/31/46	377	..	4.0	.05	..	..	..	311	68	4.6	..	..	200	200	0	7.5
So 136	141	Pleistocene gravel	12/4/45	273	..	1.0	.75	..	..	..	292	12	5.6	..	..	200	200	0	7.5
So 145	157	Hamilton formation	10/23/46	250	..	.2	.2	..	..	..	265	13	2.2	..	..	260	217	43	7.7
So 164[b]	78	Gilboa and Hamilton fms.	9/10/47	94	12	.36	.0	17	5.9	7.2	84	11	.8	0.2	.0	66	66	0	7.4
So 175	100	Gilboa and Hamilton fms.	10/31/46	135	..	.25	.15	..	..	..	140	5.6	.6	..	..	84	84	0	7.9
So 214	85	Onondaga limestone	11/12/46	481	..	.15	.01	..	..	..	377	51	26	..	..	380	309	71	7.2
So 247	300	Becraft to Coeymans limestones	11/19/45	1,159	..	2.0	.25	..	..	..	293	434	140	..	..	580	240	340	7.4
So 260	130	Rondout and Cobleskill limestones	11/19/45	344	..	.2	.015	..	..	..	350	8.7	15	..	..	180	180	0	8.0
So 266	216	Esopus siltstone	8/5/46	289	..	.05	.01	..	..	..	284	35	1.8	..	..	240	233	7	7.7
So 272	106	Schenectady formation	8/5/46	381	..	.6	.35	..	..	..	309	28	34	..	..	260	253	7	7.4
So 277	435	New Scotland to Schenectady fms.	8/5/46	517	..	.15	.01	..	..	..	406	51	50	..	..	300	300	0	7.4
So 329	213	Pleistocene deposits	8/5/46	284	..	1.5	.5	..	..	..	275	..	1.4	..	..	190	190	0	7.7
So 336	415	Esopus siltstone	10/24/46	858	..	.08	.01	..	..	..	253	1.7	390	..	..	140	140	0	8.1
So 352	240	Hamilton formation	8/9/46	170	..	1.3	.13	..	..	..	95	20	9.0	..	..	120	78	42	6.4
So 415	101	Coeymans and Manlius limestones	11/12/46	464	..	2.2	.01	..	..	..	387	40	11	..	..	240	240	0	7.5
So 424	120	Pleistocene sand	11/27/25	635	..	2.5	.2	..	..	..	392	.2	180	..	..	180	180	0	7.3
So 430	80	Pleistocene gravel	11/1/46	272	..	1.3	.2	..	..	..	277	23	.2	..	..	220	220	0	7.6
So 539	140	Onteora formation	10/25/46	162	..	.15	.13	..	..	..	176	9.2	.8	..	..	124	124	0	7.7
So 574	290	Onteora formation	11/12/46	176	..	.15	.012	..	..	..	179	2.7	.2	..	..	76	76	0	8.1
So 595	191	Onteora formation	10/25/46	142	..	.4	.01	..	..	..	111	12	.8	..	..	82	82	0	7.5
So 44Sp, 45Sp	..	Manlius and Rondout limestones	10/24/46	300	..	.05	.01	..	..	..	287	36	1.4	..	..	260	235	25	7.7
So 49Sp	..	....	8/5/46	312	..	.15	.01	..	..	..	299	13	11	..	..	80	80	0	8.1
So 109Sp	..	....	10/25/46	51	..	.05	.01	..	..	..	34	7.9	1.0	..	..	14	14	0	6.5
So 139Sp	..	....	10/25/46	36	..	.03	.01	..	..	..	11	3.8	.4	..	..	18	9	9	5.9

[a] fms., formations.
[b] Analysis by U. S. Geological Survey, Quality of Water Branch.

Relation to depth.—Generally the mineral content of ground water increases with depth. This is attributed to the fact that water in the deeper zone has passed through a greater thickness of rock and also is moving more slowly than water in the near-surface zone. Records available for wells in Schoharie County show that wells with depths less than 250 feet and wells with depths more than 250 feet have average total dissolved solids of 383 parts per million and 569 parts per million respectively. Four wells with depths of 300 feet and over show average total dissolved solids of 728 parts per million.

Relation to rock type.—The average of total dissolved solids for wells is 412 parts per million as compared to 164 parts per million for springs. Analyses of water for 3 wells in consolidated formations show an average of total dissolved solids of 426 parts per million whereas 11 analyses of water in unconsolidated deposits show an average of 282 parts per million. Dug wells and springs on the "2,000-foot plateau" and the Catskill Mountains, and drilled wells in the Hamilton, Gilboa and Onteora formations in the same area generally have a content of total solids of less than 200 parts per million. Dug wells and springs in the limestone belt may have a high mineral content.

Of the 40 wells and springs sampled, 14 showed a total hardness of less than 150 parts per million, and of these only five were less than 50 parts per million. With few exceptions the softer waters were from wells on the uplands and in the southern part of the County. As would be expected, water from drilled wells in the limestone belt in the northern part of the County generally had a hardness of over 200 parts per million. Water from dug wells in glacial drift and water flowing from springs in the limestone likewise had about the same degree of hardness. Water from wells in the Schenectady formation, which is composed of shales and sandstones, and water from wells in the Marcellus shales of the Hamilton group also had an average total hardness greater than 200 parts per million.

Hardness.—The most common term associated with the chemical quality of ground water is hardness. The hardness caused by calcium and magnesium equivalent to the bicarbonate in water is designated carbonate or temporary hardness. The remaining calcium and magnesium may combine with the sulfates, nitrates, and chlorides to form noncarbonate or permanent hardness. Although the total hardness is the sum of the carbonate and noncarbonate hardness, not infrequently the total hardness is entirely carbonate hardness and in such cases there is no noncarbonate hardness. Moreover, if hard water is boiled, the bicarbonate is decomposed and most of the calcium corresponding to the bicarbonate is precipitated as calcium carbonate, consequently a reduction of the total hardness is effected by a reduction of the carbonate hardness. Since the carbonate hardness may be appreciably reduced, it is the noncarbonate hardness which is the prime function of hard waters suitability for industrial use, for it is essentially this component of hardness which forms a hard cement like scale on well screens, boilers, and pipes.

Of the water analyzed from 33 wells, 20 samples had no noncarbonate hardness and the average carbonate hardness for these 20 wells was 187 parts per million. However the average total hardness for all well water analyzed (35 sampless) was 250 parts per million. The mean total hardness for analyses of 24 wells with water in consolidated formations was 254 parts per million and only 13 parts per million less for water in unconsolidated deposits of 11 wells.

Iron.—The distribution of iron in the ground waters of Schoharie County does not appear to be determined by any particular formation or confined to any particular locality. Of the 40 analyses, 14 showed concentrations of iron greater than 1 part per million and ten show concentrations less than 0.1 part per million. High concentrations of iron appear to be generally lacking in spring waters, probably because the iron is removed by aeration. All the bedrock formations contain varying amounts of iron which may be dissolved by circulating ground water. Water from wells ending in glacial drift seems to have an average concentration of 1.7 parts per million.

Manganese.—When present in quantities greatly exceeding 0.05 part per million manganese causes gray to black discolorations on many of the materials that it encounters. It also causes clogging deposits in piping and is particularly troublesome in laundry and textile plants. Fourteen of the analyses in table 4 showed over 0.05 part per million of manganese and the mean manganese content was 0.12 part per million.

Chloride.—The United States Public Health Service recommends 250 parts per million as a limit for chloride in potable waters. Only one well (So 336) in Schoharie County yields water which is over this limit, and this is used only for cooling. Only three wells yield water which is over 140 parts per million of chloride. There does not appear to be any close correlation between the chloride or sulfate content of the well waters and the formations from which they are obtained, but in general, these constituents are more likely to be present in high concentrations in the deeper wells.

Sulfate.—The highest concentration of mineral constituents in any of the ground waters in the county is in the mineral spring waters at Sharon Springs. These waters seem to be characterized by a high concentration of sulfates, principally calcium and magnesium. Magnesium sulfate is more commonly known as Epsom salts. As was indicated in the discussion of the geologic formations, these springs are situated at or near the contact of the Brayman shale, which contains pyrite (iron sulfide) and the Cobleskill dolomitic limestone. It is probable that the calcium and magnesium in the water are derived from the Cobleskill and the sulfur from the Brayman. The springs are also characterized by the presence of considerable amounts of hydrogen sulfide gas. The concentration of dissolved minerals in the springs is such that deposits of tufa have formed around former spring openings, and similar deposits are still forming in the present openings and in the stream carrying the discharge from the springs. Many of the drilled wells in the village of Sharon Springs yield highly mineralized water and have been abandoned for that reason. Well So 11, for which a partial analysis is available is about 2 miles east of Sharon Springs, and although low in sulfates, has a content of total solids of 812 parts per million.

Hydrogen-ion concentration (pH).—The hydrogen-ion concentration of a water is expressed by the unit pH, and its importance lies in its indication of the corrosiveness of the water. The pH of a water is the negative exponent of the concentration of hydrogen-ions in grams per liter. Thus a low pH value means a high concentration of hydrogen-ions, or a high acidic value, and a high pH value indicates a low concentration of hydrogen-ions, or a low acidic value. A neutral water has a pH of 7.0. The waters analyzed from Schoharie County show a range in pH from 5.9 to 8.7 and an average value of 7.4. The pH value should be determined immediately after the sample is collected because changes in the alkalinity of the water occur upon contact with the air. The analyses in table 4 were not made until several days after the samples were collected, and pH values reported may not be representative of the original waters as they came from the wells and springs.

The village of Mineral Springs is believed to be named from the occurrence of a spring (So 49Sp) at this location, the analysis of which is shown in table 4. This water is no more highly concentrated than many of the well waters in Schoharie County, although it reportedly contains hydrogen sulfide gas, which is not shown in the analysis.

Temperature

The temperature of water used for cooling or air-conditioning purposes is of more importance than its chemical characteristics. Water with consistently low temperature is preferred and in this respect ground water is vastly superior to surface water. The temperature of stream waters directly reflects the local atmospheric conditions and may range from 32°F. to more than 80°F. throughout the course of a year. The temperature of ground water, however, generally remains within a few degrees of the mean annual air temperature of the region, regardless of the season.

The mean annual air temperature of Sharon Springs and Middleburg for a period from 1936 to 1945 is 46°F. Ground-water temperatures from the whole County were averaged into 2 groups. Wells under 30 feet deep had an average temperature of 50°F. and those over 30 feet averaged 46.7°F. This comparison, using only 2 localities for mean annual air temperature, is necessarily only an approximation of the relationship between air and ground-water temperatures. Collins[48] has stated that ground water obtained from depths between 20 and 200 feet will range from 3 to 6 degrees F. above the mean annual air temperature. This conforms to the results obtained in Schoharie County.

[48] Collins, W. D., Temperature of water available for industrial use in the United States: U. S. Geol. Survey Water-Supply Paper 520, p. 98, 1925.

SUMMARY OF GROUND-WATER CONDITIONS

The occurrence of ground water is of considerable importance in Schoharie County because almost all the private supplies and most of the public supplies are obtained from wells and springs. The County is underlain by bedrock ranging in age from Middle Ordovician to Upper Devonian, and consisting of sandstones, siltstones, shales, and limestones. With few exceptions ground water is contained in these formations in joint cracks and along bedding planes, as the indurated rocks have very little pore space. In the shales and siltstones, the joints tend to be fairly closely spaced, whereas in the sandstones and limestones they are spaced more widely. The joints may be classified in three sets with average strikes of N. 57° W., N. 29° W., and N. 55° E. In the massive limestone formations, the joints are commonly enlarged by solution and form sinks, caverns, and some fairly large springs. Wells tapping the rocks of Middle Ordovician to Lower Devonian age generally have yields between 5 and 10 gallons a minute, and the water is hard and frequently highly mineralized. The massive limestones in this interval may or may not yield large supplies of water, depending on whether or not enlarged water-bearing joints are encountered by wells. Wells in the Middle and Upper Devonian rocks generally have yields between 10 and 20 gallons a minute. The water from the Onondaga limestone is hard, and the water from the Marcellus shale is frequently fairly highly mineralized, but the water from the higher formations is low in mineral content.

Wells in the unconsolidated glacial deposits yield small to moderate supplies of water. Those in till and clay usually yield less than 10 gallons a minute, but those in stratified sand and gravel usually yield more than 20 gallons of water a minute.

The chemical quality of water from wells in the glacial drift depends in part on the underlying bedrock and in part on the character of the material composing the drift. Thus, wells in drift underlain by limestone or containing many fragments of limestone yield hard water.

The principal areas of stratified sands and gravels are the Catskill Valley area, the Manorkill area, the Broome Center area, and the Jefferson area. Most of the material in the Schoharie, Cobleskill and Fox Creek Valleys is clay or clayey till, although gravel beds often occur at depth. It is doubtful whether large permanent supplies of ground water can be obtained in these areas.

Supplies of ground water of satisfactory quality and of sufficient quantity for domestic and farm use can be obtained almost anywhere in the County from dug and drilled wells, and in many cases from springs. However, it is questionable whether large permanent supplies of ground water suitable for industrial use can be developed from any of the bedrock formations or from the glacial drift in the Schoharie, Cobleskill and Fox Creek Valleys and in the northern part of the County generally. Possibly such supplies might be obtained from the stratified sands and gravels in the southern part of the County, but as yet no large yielding wells have been developed in this area and the potentialities are not too promising.

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Table 5.—Logs of selected wells in Schoharie County, New York.

(See table 6 and plate 2 for records and locations of wells.)

So 35. Seth Ullman, owner; Sharon Springs, N. Y.; Ruderhouser, driller:

	Thickness (feet)	Depth (feet)
Sand and gravel	26	26
Limestone	86	112

So 45. A. Olson, owner; Carlisle, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Soil	2	2
Limestone	138	140

So 46. H. J. Hyney, owner; Carlisle, N. Y.; Adams, driller:

	Thickness (feet)	Depth (feet)
Limestone	40	40
Shale	96	136

So 50. Martin Tanzmann, owner; Carlisle, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Blue clay	80	80
Light grey hardpan	10	90
Shale	80	170

So 94. L. P. Diefendorf, owner; Gardinersville, N. Y.; Belyea, driller:

	Thickness (feet)	Depth (feet)
Blue clay	35	35
Hard sandstone	40	65

So 98. D. A. Weaver, owner; Seward, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Clay and hardpan	32	32
Fine sand	6	38
Boulders	1	39
Fine sand	7	46
Hardpan	18	64
Fine sand	1	65
Shale	21	86

So 113. Ethel Holmes, owner; Hyndsville, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Hardpan and clay	8	8
Blue clay	141	149
Sand	1	150
Limestone	—	—

So 119. Tom Barber, owner; Hyndsville, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Yellow clay	10	10
Fine sand and clay	15	25
Blue clay	25	50
Sand and clay	30	80
Blue clay	90	170
Hardpan	3	173
Hard fine sand	18	191
Black shale	8	199

Table 5.—Logs of selected wells in Schoharie County, New York. (Continued)
(See table 6 and plate 2 for records and locations of wells.)

So 126. W. M. Hynds, owner; Warnerville, N. Y.; Stewart Bros., driller

	Thickness (feet)	Depth (feet)
Till	68	68
Shale	12	80
Limestone	145	225

So 149. E. Waldron, owner; Richmondville, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Hardpan	41	41
Shale	51	92

So 179. H. C. Makley, owner; Charlottesville, N. Y.; J. Van Loan, driller:

	Thickness (feet)	Depth (feet)
Earth	6	6
Blue clay	16	22
Blue sandstone	316	338

So 194. M. Francis, owner; Charlottesville, N. Y.; J. Van Loan, driller:

	Thickness (feet)	Depth (feet)
Earth	35	35
Quicksand	4	39
Blue clay with boulders	18	57
Grey sandstone	4	61

So 195. W. C. Irwin, owner; Charlottesville, N. Y.; W. L. Hamilton, driller:

	Thickness (feet)	Depth (feet)
Hardpan, boulders	40	40
Shale	165	205

So 217. Mrs. C. Ottman, owner; Central Bridge, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Soil	12	12
Limestone	167	179
Shale	53	232

So 229. Stan Gordon, owner; Central Bridge, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Clay and hardpan	80	80
Quicksand	40	120
Clay and hardpan	70	190
Quicksand	16	206

So 234. Lambert Nethaway, owner; Howes Cave, N. Y.; Stewart Bros., driller:

	Thickness (feet)	Depth (feet)
Clay and boulders	60	60
Limestone	208	268

So 237. Clayton Briggs, owner; Cobleskill, N. Y.; H. W. Provost, driller

	Thickness (feet)	Depth (feet)
Hardpan	10	10
Limestone	93	103
Softer rock	53	156

Table 5.—Logs of selected wells in Schoharie County, New York. (Continued)

(See table 6 and plate 2 for records and locations of wells.)

So 240. Robert Lamont, owner; Cobleskill, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Hardpan	13	13
Limestone	78	91
White limestone, softer	39	130
Soft rock	80	210
Hard rock	28	238
Shale	112	350

So 247. Village of Cobleskill, owner; Cobleskill, N. Y.; Hall & Co., Inc., driller:

	Thickness (feet)	Depth (feet)
Top soil	10	10
Clay	25	35
Gravel, clay, hardpan	50	85
Hard clay	20	105
Oriskany sandstone	10	115
Becraft limestone	20	135
New Scotland shale	137	272
Coeymans limestone	28	300

So 248 Village of Cobleskill, owner; located approximately 2,000 feet west of well So 247; Hall & Co. Inc., driller:

	Thickness (feet)	Depth (feet)
Clay-filled fine gravel	26	26
Moist clay	15	41
Clay and fine sand, moist	49	90
Medium fine sand, water, artesian flow 15-35 gallons per minute	2	92
Fine sand, clay	4	96
Sand with clay	3	99
Clay and gravel hardpan	31	130
Bedrock	—	130

So 254. J. Nethaway and Son, owner; Howes Cave, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Clay and hardpan	285	285
Gravel	5	290

So 259. North American Cement Corp., owner; Howes Cave, N. Y.; Hall & Co. Inc., driller:

	Thickness (feet)	Depth (feet)
Blue limestone	65	65
Shale	130	195
Blue limestone and shale	25	220
Blue limestone	12	232
Shale, limestone, and other	348	580

So 266. M. Moseman, owner; East Cobleskill, N. Y.; Stewart Bros., driller:

	Thickness (feet)	Depth (feet)
Earth	4	4
Onondaga limestone	106	110
Esopus shale	106	216

Table 5.—Logs of selected wells in Schoharie County, New York. (Continued)

(See table 6 and plate 2 for records and locations of wells.)

So 277. Willard Wright, owner; Schoharie, N. Y.; Stewart Bros., driller:

	Thickness (feet)	Depth (feet)
Sand and clay (boulder at 50 feet depth)	85	85
Shale and limestone	350	435

So 279. W. Wilber, owner; Schoharie, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Clay and hardpan	225	225
Shale	181	406

So 287. William G. Brown, owner; Schoharie, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Clay and hardpan	19	19
Hard rock	97	116
Shale	20	136
Rock with iron pyrite	12	148
(Record missing)	55	203

So 312. J. Schaeffer, owner; Schoharie, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Unconsolidated material	62	62
Limestone	18	90
Shale	29	119

So 321. Blue Gables Cabins, owner; Middleburg, N. Y.; J. Van Loan, driller:

	Thickness (feet)	Depth (feet)
Clay	140	140
Gravel	5	145

So 323. E. Borsell, owner; Middleburg, N. Y.; Richardson Bros., driller:

	Thickness (feet)	Depth (feet)
Earth	5	5
Flint and limestone	145	150

So 348. Hillview Ranch, owner; Middleburg, N. Y.; J. Van Loan, driller:

	Thickness (feet)	Depth (feet)
Clay and gravel	200	200
Black shale and limestone	300	500

So 360. L. Lagger, owner; Fultonham, N. Y.; Maline, driller:

	Thickness (feet)	Depth (feet)
Till	20	20
Gravel	10	30
Clay	70	100

So 372. G. Hilts, owner; Bouck's Falls, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Earth	7	7
Shale	33	40
Hard rock	117	157

Table 5.—Logs of selected wells in Schoharie County, New York. (Continued)

(See table 6 and plate 2 for records and locations of wells.)

So 378. S. Palmer, owner; Middleburg, N. Y.; driller not known:

	Thickness (feet)	Depth (feet)
Boulders and earth	90	90
Gravel	5	95
Boulders	75	170
Sand	16	186

So 394. H. Wilber, owner; Franklinton, N. Y.; Richardson Bros., driller:

	Thickness (feet)	Depth (feet)
Yellow hardpan	80	80
Gravel	2	82

So 402. Otto Schuck, owner; Franklinton, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Soil	5	5
Red shale	177	182
Slate rock	56	238

So 408. Willard Mann, owner; Breakabeen, N. N.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Sand and gravel	20	20
Blue clay	20	40
Sand	16	56

So 415. Francis Masterson, owner; Delanson,N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Clay and boulders	85	85
Limestone	16	101

So 418. Harry Gallup, owner; Schoharie, N. Y.; H. W. Provost, driller:

	Thickness (feet)	Depth (feet)
Clay and hardpan	105	105
Black sand and gravel	4	109

So 421. Mrs. C. Panas, owner; Quaker Street, N. Y.; Torlish, driller:

	Thickness (feet)	Depth (feet)
Clay and boulders	69	69
Blue sandstone	22	91

So 424. Norman D. Newcomb, owner; Gallupville, N. Y.; Hall & Co. Inc., driller:

	Thickness (feet)	Depth (feet)
Hardpan and Clay	100	100
Sand	20	120

So 430. Randall Decker, owner; Gallupville, N. Y.; Weaver, driller:

	Thickness (feet)	Depth (feet)
Soil	3	3
Gravel	7	10
Hardpan	4	14
Gravel	4	18
Hardpan and clay	57	75
Sand	5	80

Table 5.—Logs of selected wells in Schoharie County, New York. (Concluded)

(See table 6 and plate 2 for records and locations of wells.)

		Thickness (feet)	Depth (feet)
So 467.	Tomkins Saw Mill, owner; Broome Center, N. Y.; Kellerhouse and Stoutenberg, driller:		
	Blue and brown hardpan, with many cobbles	105	105
	Sandstone, occasional layers of soft rock	67	172
So 541.	Mrs. Sens, owner; Manorkill, N. Y.; Tallman, driller:		
	Clay	90	90
	Sand	43	133
	Bedrock	3	136
So 649.	Village of Cobleskill, owner; Cobleskill, N. Y.; Hall & Co., Inc., driller:		
	Clay	40	40
	Moist sand and clay	16	56
	Fine sand (produced flow of 2 to 3 gallons per minute)	4	60
	Bedrock	—	—
So 650.	Village of Cobleskill, owner; Cobleskill, N. Y.; Hall & Co. Inc., driller:		
	Sand, gravel and clay	7	7
	Clay, gravel hardpan	48	55
	Clay	32	87
	Fine sand, moist clay (produced flow of about 2 gallons per minute)	5	92
	Bedrock	—	—

Table 6.—Records of selected wells in Schoharie County, New York.

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
So 3	10V, 4.7N, 6.8W	E. Herman	1,260	Drl	91	6	60	Rondout-Cobleskill limestone	12	..	..	50	Farm	
So 4	10V, 4.4N, 6.8W	C. D. Eldredge	1,360	Drl	71	6	..	Manlius limestone	..	..	..	..	Dom	Water reported to be hard.
So 11	10V, 3.2N, 4.4W	E. Ciperley	1,320	Drl	144	6	30	Rondout-Cobleskill limestone	90	..	..	..	Farm	Water reported to be hard.[g]
So 14	10V, 2.7N, 0.7W	Nick Hataskoi	1,110	Drl	92	6	92	Pleistocene deposits	12	Force	6	..	Farm	Water reported to be hard.[g]
So 15	10V, 3.4N, 7.7W	M. Lynk	1,400	Drl	162	6	10	Coeymans-Manlius limestone	112	Force	..	..	Dom	Water reported to contain hydrogen sulfide.
So 16	10V, 3.2N, 7.5W	S. Karper	1,360	Drl	186	6	..	Coeymans-Manlius limestone	60	Force	..	..	Com	Water reported to be hard and contain magnesium salts.
So 17	10V, 3.1N, 7.1W	S. Karper	1,360	Drl	186	..	..	Coeymans-Manlius limestone	..	Force	..	..	Farm	Water reported to be hard.
So 20	10V, 2.8N, 6.6W	V. S. LaVallee	1,350	Drl	280	..	..	New Scotland-Coeymans-Manlius limestone	160	Force	11	..	Dom	
So 27	10V, 0.9N, 4.1W	G. Xenidis	1,500	Drl	152	6	..	Becraft-New Scotland limestone	..	..	..	..	Dom	Water reported to be hard.
So 34	10V, 0.4N, 2.2W	J. Eldredge	1,260	Drl	154	6	7	Rondout limestone	139	..	0.7	..	Com	Water reported to contain magnesium salts.
So 35	10V, 0.8N, 1.9W	Seth Ullman	1,220	Drl	112	6	26	Rondout limestone	100	..	5	..	Farm	Three other drilled wells on this property 146, 175 and 175 feet. Water from these deeper wells unpotable due to hydrogen sulfide content.
So 36	10V, 0.8N, 1.8W	F. Wainright	1,200	Drl	90	..	0	Coeymans-Manlius limestone	82	Force	..	..	Com	
So 39	10V, 0.5N, 0.7W	E. Metzger	1,140	Drl	120	..	..	Manlius limestone	..	..	..	..	Com	
So 43	10V, 0.2N, 5.5W	H. Mereness	1,320	Drl	72	6	30	Onondaga limestone	16	..	12	..	Farm	([g])
So 45	10V, 0.5N, 0.7E	A. Olson	1,320	Drl	140	6	2	Rondout limestone	75	Force	..	..	Dom	
So 46	10V, 0.5N, 0.9E	H. J. Hyney	1,320	Drl	136	3	0	Rondout limestone	..	Force	..	..	Farm	
So 47	10V, 0.5N, 1.4E	Edward Smullen	1,320	Drl	140	6	..	Rondout limestone	..	..	15	..	Dom	
So 49	10V, 0.5N, 2.4E	Leo Tillapaugh	1,320	Drl	360	6	..	Schenectady formation	30	Force	0.12	..	Farm	Water reported to be soft.[g]
So 50	10V, 0.5N, 2.6E	Martin Tanzmann	1,280	Drl	170	6	90	Brayman shale-Schenectady formation	21	..	1.5	..	Com	
So 51	10V, 0.5N, 2.8E	J. W. Jensen	1,240	Drl	110	6	..	Schenectady formation	..	Jet	12	53	Com	
So 55	10V, 0.5N, 5.0E	James Millen	1,210	Drl	185	..	..	Schenectady formation	..	Force	..	..	Dom	Water reported to be hard.
So 57	10V, 0.5N, 6.8E	William Van Sise	1,100	Drl	200	6	..	Schenectady formation	..	Jet	7	..	Com	([g])
So 58	10V, 0.5N, 7.1E	Steve Garger	1,090	Drl	290	6	..	Schenectady formation	50	..	2.6	..	Com	Water yield reported to be 1 gallon per minute at 107 feet and 2¾ gallons per minute at 152 feet.

See footnotes at end of table.

Table 6.—Records of selected wells in Schoharie County, New York. (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
So 59	10V, 0.5N, 8.4E	Art Johnson	680	Drl	87	6	12	Schenectady formation	..	..	1.3	..	Com	Water reported to be hard.
So 62	10V, 0.5N, 9.8E	Russell Fancher	660	Drl	152	6	..	Schenectady formation	..	Jet	..	..	Farm	Water reported to be soft and to contain hydrogen sulfide.
So 64	10V, 0.5N, 10.2E	Roy Starke	600	Drl	120	6	95	Schenectady formation	..	Centrifugal	1	..	Dom	Well reported to flow without pumping at rate of 1 gallon per minute originally and to contain hydrogen sulfide.
So 71	10V, 1.8N, 11.3E	Joseph Collins Farm	1,190	Drl	210	6	..	Schenectady formation	..	..	5	..	Farm	Water reported to be hard.
So 73	10V, 1.4N, 11.8E	H. W. Rockwell	860	Drl	300	6	..	Schenectady formation	..	Force	..	..	Farm	Water reported to be hard.
So 74	10V, 1.1N, 12.1E	Mrs. L. Rector	720	Drl	85	6	..	Schenectady formation	..	Pitcher	6	..	Dom	Water reported to be hard.
So 75	10V, 0.6N, 12.2E	Walt Hunter	580	Drl	214	6	186	Schenectady formation	..	Centrifugal	9	..	Dom	Rock reported at 38 feet. Water reported to contain hydrogen sulfide.[g]
So 76	10V, 0.7N, 12.1E	Mrs. Fuller	600	Drl	60	6	6	Schenectady formation	..	Suction	..	..	Farm	Water reported to contain hydrogen sulfide.
So 77	10V, 0.7N, 12.4E	A. J. McIntosh	580	Drl	37	6	37	Pleistocene deposits	7	Suction	..	..	Dom	Water reported to be hard.
So 78	10V, 0.7N, 12.6E	Jerry Hardin	600	Drl	78	6	..	Schenectady formation	..	Force	3.5	..	Com	Water reported to be hard.
So 79	10V, 0.7N, 12.6E	M. E. Parsonage	580	Drl	136	6	60	Brayman shale-Schenectady formation	..	Force	2	..	Dom	Water reported to be soft.
So 80	10V, 0.7N, 12.6E	Ernest Brown	500	Drl	125	6	62	Brayman shale-Schenectady formation	..	..	9	..	Com	Well reported to flow without pumping at rate of 9 gallons per minute on December 10, 1945.
So 81	10V, 1.0N, 12.6E	Roland V. Gage	560	Drl	192	6	150	Brayman shale-Schenectady formation	10	Force	..	..	Dom	Water reported to be hard.
So 82	10V, 0.9N, 12.2E	Esperance School	630	Drl	70	6	..	Brayman shale-Schenectady formation	..	Pitcher	68	..	Dom	Rock encountered at 1½ feet.
So 83	10V, 1.0N, 12.4E	E. McCarty	630	Drl	100	6	10	Brayman shale-Schenectady formation	5	Force	1.5	..	Farm	Water reported to be soft.
So 84	10V, 1.0N, 12.6E	J. L. Gage	560	Drl	154	4	104	Brayman shale-Schenectady formation	..	Force		..	Dom	Water reported to be hard and to flow without pumping at rate of 1 gallon per minute.[g]
So 85	10V, 1.0N, 12.4E	E. McCarty	640	Drl	81	6	8	Brayman shale-Schenectady formation	5	Suction	1.5	..	Dom	Water reported to be hard and to flow without pumping at rate of 1 gallon per minute.[g]
So 89	10V, 0.6S, 4.6W	George M. Pindar	1,380	Drl	184	6	80	Onondaga limestone	..	Force	..	..	Farm	Water reported to be hard.
So 94	10V, 1.6S, 3.6W	L. P. Diefendorf	1,400	Drl	65	..	85	Hamilton formation	15	Force	18	..	Farm	
So 95	10V, 1.8S, 4.1W	F. Brown	1,400	Drl	260	6	253	Hamilton formation	48	Force	..	..	Farm	([g])
So 98	10V, 2.2S, 5.8W	D. A. Weaver	1,180	Drl	86	6	65	Hamilton formation	1	Suction	1.3	..	Farm	([g])

See footnotes at end of table.

Table 6.—Records of selected wells in Schoharie County, New York. (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
So 99	10V, 2.2S, 5.6W	Sheffield Farms, Inc.	1,180	Drl	130	5	..	Marcellus shale	..	Suction	..	48	Farm	Well reported to flow without pumping.
So 109	10V, 2.9S, 4.1W	J. C. Handy	1,200	Drl	118	6	118	Marcellus shale	106	Force	12	..	Dom	Onondaga limestone reported at bottom of well.
So 110	10V, 2.2S, 2.0W	B. C. Hotaling	1,400	Drl	124	6	40	Marcellus shale	6	Force	6	..	Farm	
So 113	10V, 3.7S, 2.5W	Ethel Holmes	1,240	Drl	150	6	150	Pleistocene sand	+13	..	6	..	Farm	Well reported to flow without pumping at rate of 6 gallons per minute on December 6, 1945.
So 114	10V, 3.4S, 1.7W	Fred Leon	1,320	Drl	160	6	33	Marcellus shale	..	Force	8.1	..	Dom	Well reported to flow at rate of 1 gallon per minute at 120 feet, 2 gallons per minute 146 feet and 8 gallons per minute at 160 feet.
So 115	10V, 3.1S, 0.3W	S. Hutton	1,224	Drl	191	6	0	Esopus siltstone	50	Force	10	..	Com	
So 116	10V, 3.3S, 0.4W	Lewis Utter	1,200	Drl	190	6 to 4	145	Onondaga limestone	60	Force	6	..	Com	
So 117	10V, 3.3S, 0.2W	Charles Larkin	1,250	Drl	208	6	208	Becraft limestone	..	Force	..	..	Farm	
So 119	10V, 4.6S, 4.1W	Tom Barber	1,160	Drl	199	6	191	Marcellus shale	2	Pitcher	16	..		
So 122	10V, 5.1S, 1.8W	Stephen Wood	1,200	Drl	360	6	..	Pleistocene till	100	Force	..	..	Farm	(g)
So 124	10V, 4.8S, 0.3W	Mrs. Blanche Shafer	1,100	Drl	68	6	68	Pleistocene till	..	Force	..	..	Farm	Water reported to be hard and to contain hydrogen sulfide.
So 126	10V, 5.4S, 0.7W	W. M. Hynds	1,040	Drl	225	6	68	Onondaga limestone	6	..	30	49	Dom	
So 127	10V, 5.6S, 0.8W	I. J. Ostrander	1,360	Drl	120	6	..	Onondaga limestone	10	Pitcher	..	..	Farm	
So 128	10V, 5.7S, 0.2W	Harry D. Twombley	940	Drl	60	6	60	Pleistocene sand	..	Suction	1	45	Com	Well reported to flow without pumping.
So 131	10V, 6.8S, 5.9W	S. De Braccio	1,360	Drl	98	6	10	Hamilton formation	..	Force	7	..	Com	
So 133	10V, 8.0S, 4.5W	L. Bailey	1,600	Drl	269	6	6	Hamilton formation	100	Force	15	40	Farm	
So 134	10V, 7.4S, 4.7W	John Palmer	1,220	Drl	35	6	35	Pleistocene deposits	2	Suction	..	..	Farm	Shale reported from 0 to 100 feet, sandstone from 100 feet to 269 feet.
So 135	10V, 7.2S, 3.5W	James H. Cunklin	1,040	Drl	88	6	10	Onteora formation	..	Jet	8	..	Farm	
So 136	10V, 6.9S, 1.7W	Dan Manchester	960	Drl	141	6	141	Pleistocene gravel	+20	..	16	..	Farm	Water reported to be soft and to contain mineral taste. Water reported to flow without pumping.[g]
So 137	10V, 7.3S, 1.8W	Otto Lindeck	1,000	Drl	..	..	..		..	Suction	..	..	Dom	Water reported to contain hydrogen sulfide.
So 138	10V, 6.8S, 1.2W	Henry Moore	950	Drl	150	6	110	Marcellus shale	..		0.1	..	Com	Water reported to contain hydrogen sulfide.
So 139	10V, 8.0S, 1.2W	F. Goodenough	1,560	Drl	100	6	9	Hamilton formation	52	Force	8	..	Farm	

See footnotes at end of table.

Table 6.—Records of selected wells in Schoharie County, New York. (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
So 143	10V, 8.0S, 2.0W	C. B. Frasier	1,080	Drl	140	6	140	Pleistocene sand	3	Suction	..	48	Dom	
So 145	10V, 8.4S, 3.9W	H. S. Thurber	1,300	Drl	157	6	87	Hamilton formation	30	Force	..	..	Farm	Water reported to be hard and to contain iron.[g]
So 148	10V, 8.8S, 4.9W	E. Waldron	1,840	Drl	100	6	..	Hamilton formation	..	..	..	..	Dom	Well drilled at a later time than well No. 149 and affects its water supply.
So 149	10V, 8.7S, 5.1W	E. Waldron	1,860	Drl	92	6	41	Hamilton formation	..	..	7	..	Dom	Water reported to be carbonated and to flow without pumping.
So 163	10V, 10.8S, 4.1W	E. Wharton	2,060	Drl	140	6	..	Gilboa-Hamilton formation	..	Force	10	..	Farm	Water reported to be hard.
So 164	10V, 11.1S, 4.9W	I. Demarest	2,120	Drl	78	6	7	Gilboa-Hamilton formation	7	Suction	..	..	Dom	([g])
So 165	10V, 11.5S, 7.2W	R. Armbruster	1,900	Drl	90	6	90	Pleistocene gravel	1	Suction	..	..	Farm	Water reported to be hard.
So 167	10V, 11.7S, 4.5W	C. J. Wharton	2,160	Drl	78	6	..	Gilboa-Hamilton formation	18	Suction	..	..	Dom	
So 168	10V, 12.0S, 4.7W	C. J. Wharton	2,120	Drl	108	6	108	Gilboa-Hamilton formation	25	Force	5	..	Dom	Water reported to be soft.
So 169	10V, 12.0S, 4.7W	H. B. Van Valen	2,110	Drl	135	6	3	Gilboa-Hamilton formation	..	Suction	5	..	Dom	
So 170	10V, 11.9S, 4.5W	R. Hellyas	2,100	Drl	68	6	6	Gilboa-Hamilton formation	22	Force	4	..	Dom	
So 171	10V, 12.0S, 4.3W	C. Irving	2,060	Drl	120	6	20	Gilboa-Hamilton formation	30	Force	10	..	Com	
So 175	10V, 12.8S, 6.5W	J. Oliver	1,760	Drl	100	6	50	Gilboa-Hamilton formation	6	Suction	5.5	45	Farm	([g])
So 179	10V, 13.0S, 7.5W	H. C. Makley	1,690	Drl	338	6	22	Gilboa-Hamilton formation	22	Force	20	..	Farm	No drawdown reported after 2 hours pumping.
So 186	10V, 14.3S, 8.4W	Sperbeck's Store	1,600	Drl	150	6	..	Gilboa-Hamilton formation	..	Force	30	..	Dom	
So 188	10V, 14.3S, 8.6W	D. Cummings	1,600	Drl	34	6	34	Pleistocene gravel	7	Force	12	..	Com	Water reported to be soft. Hardpan and gravel reported in well.
So 192	10V, 15.2S, 10.0W	W. Madden	1,560	Drl	165	6	135	Gilboa formation	100	Force	..	45	Farm	
So 194	10V, 16.0S, 10.5W	M. Francis	1,440	Drl	61	6	57	Gilboa-Hamilton formation	8	Suction	..	40	Farm	
So 195	10V, 16.3S, 10.0W	W. C. Irwin	1,550	Drl	205	6	40	Gilboa-Hamilton formation	30	..	10	..		Drawdown reported 55 feet after pumping 10 gallons per minute for 1 hour.
So 198	10V, 14.7S, 6.2W	C. Smith	2,080	Drl	43	6	8	Gilboa-Hamilton formation	..	Suction	10	..	Dom	
So 206	10V, 16.2S, 4.1W		1,880	Drl	55	6	20	Gilboa formation	..	..	..	..		Well being drilled October 2, 1946. Well dry at 55 feet.

See footnotes at end of table.

Table 6.—Records of selected wells in Schoharie County, New York. (Continued)

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So 208	10V, 15.1S, 3.1W	G. Proper	1900	Drl	150	6	42	Gilboa-Hamilton formation	135	Force	14	..	Farm	
So 212		George Sheesech	1,280	Drl	163	6	18	Coeymans-Manlius limestone	123	Force	..	..	Farm	
So 213	10V, 0.6S, 2.4E	Floyd Snyder	1,310	Drl	700	6	68	Schenectady formation	140	..	..	38	Farm	Well abandoned.
So 214	10V, 1.2S, 2.8E	Howard Baker	1,420	Drl	85	6	..	Onondaga limestone	40	Force	..	46	Farm	(g)
So 215	10V, 0.8S, 3.6E	Orval Elliot	1,360	Drl	160	6	15	Coeymans-Manlius limestone	40	Force	..	..	Farm	
So 216	10V, 1.2S, 3.6E	Charles Sisson	1,310	Drl	35	6	20	Coeymans limestone	7	Suction	1.5	..	Farm	Water reported to be very hard.
So 217	10V, 1.5S, 3.8E	Mrs. C. Ottman	1,300	Drl	232	6	12	Coeymans-Manlius limestone	138	Force	3.3	..	Farm	
So 218	10V, 1.6S, 3.8E	Charles Ottman	1,300	Drl	240	6	8	Coeymans-Manlius limestone	138	Force	3.3	..	Dom	
So 219	10V, 1.8S, 3.7E	Melvin Burhans	1,280	Drl	75	5	5	New Scotland limestone	..	..	..	..		Well abandoned.
So 221	10V, 2.2S, 3.1E	Cora Snyder	1,240	Drl	257	6	10	Coeymans-Manlius limestone	..	Force	..	..	Farm	Bedrock reported at 7 feet.
So 223	10V, 0.5S, 6.1E	Charles Stevens	1,020	Drl	180	6	..	Schenectady formation	..	Force	..	..	Farm	Water reported to be very hard.
So 225	10V, 1.8S, 6.9E	Harry Wright	1,100	Drl	90	5	10	Coeymans-Manlius limestone	14	..	..	..	Farm	
So 226	10V, 0.2S, 8.9E	Leslie Scutt	600	Drl	116	6	93	Schenectady formation	..	None	2	..	Farm	Well reported to flow without pumping.
So 227	10V, 0.3S, 8.3E	Charles Hagen	590	Drl	150	8	58	Schenectady formation	15	Jet	3	..	Com	Water reported to be turbid.
So 228	10V, 1.9S, 9.3E	G. E. Keyser	720	Drl	195	6	..	Schenectady formation	..	None	..	..	Dom	Water reported to be hard. Well reported to flow without pumping.
So 229	10V, 2.7S, 9.4E	Stan Gordon	670	Drl	206	6	..	Pleistocene sand	206	..	..	..	Dom	Well reported to have contained natural gas.
So 230	10V, 2.6S, 8.4E	Gilbert Zeh	610	Drl	181	6	..	Pleistocene till	..	..	..	..	Dom	Water reported to be hard and to flow without pumping.
So 231	10V, 2.6S, 6.0E	Oliver Goodfellow	1,130	Drl	137	6	..	Coeymans-Manlius limestone	..	..	..	..	Farm	
So 232	10V, 2.7S, 4.8E	Walter Rivenburg	1,170	Drl	100	6	..	Coeymans-Manlius limestone	..	Suction	..	..	Dom	
So 233	10V, 3.2S, 5.3E	G. Schench	1,120	Drl	350	6	..	Schenectady formation	..	Force	..	..	Dom	
So 234	10V, 3.5S, 4.8E	Lambert Nethaway	970	Drl	268	6	60	Coeymans-Cobleskill limestone	80	None	12	..	Farm	
So 236	10V, 3.0S, 2.7E	J. T. Mann	1,100	Drl	300	8	15	Coeymans-Cobleskill limestone	100	Force	5	..	Farm	

See footnotes at end of table.

Table 6.—Records of selected wells in Schoharie County, New York. (Continued)

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So 237	10V, 1.6S, 1.0E	Clayton Briggs	1,380	Drl	156	6	10	Onondaga limestone	100	..	0.6	44	Dom	
So 238	10V, 2.7S, 0.6E	Phil Schuyler	1,340	Drl	120	4	..	Hamilton formation	..	Force	..	..	Farm	Well reported to flow without pumping.
So 239	10V, 2.9S, 0.8E	Phil Schuyler	1,300	Drl	143	6	80	Onondaga limestone	..	Suction	..	..	Dom	
So 240	10V, 3.4S, 1.1E	Robert Lamont	1,240	Drl	350	6	13	New Scotland limestone	150	Force	0.6	..		Well abandoned because of hydrogen sulfide content.
So 242	10V, 3.8S, 1.1E	Jerry Bellinger	1,180	Drl	265	8	221	Onondaga limestone-Esopus siltstone	..	..	11	..	Farm	Bedrock reported at 10 feet.
So 244	10V, 4.3S, 0.2E	Will D. Aker	1,100	Drl	125	6	18	Onondaga limestone	12	Force	..	..	Farm	
So 245	10V, 5.0S, 0.7E	Mrs. Stacy	920	Drl	100	6	100	Pleistocene gravel	..	None	30	..	Com	Water used for theater. Well reported to flow without pumping.
So 246	10V, 5.1S, 0.6E	Schoharie Company Co-op. Dairies	910	Drl	365	8	..	Becraft-Manlius limestone	+8	None	..	..		Water unpotable due to hydrogen sulfide content. Well reported to flow without pumping.
So 247	10V, 5.3S, 0.8E	Village of Cobleskill	890	Drl	300	8	105	Becraft-Coeymans limestone	+5	None	30	..		Well reported to flow without pumping. Test well, yield too small.[g]
So 248	10V, 5.4S, 0.2E	Village of Cobleskill	910	Drl	130	8	130	Pleistocene sand	..	..	15	..		Well reported to flow without pumping. Test well, yield too small.[g]
So 250	10V, 4.8S, 2.3E	Sharon Mauhs	900	Drl	90	6	30	Oriskany sandstone-Esopus siltstone	..	Force	..	..	Farm	Water reported to contain hydrogen sulfide.
So 251	10V, 3.9S, 2.6E	Roger Becker	940	Drl	243	6	..		50	Force	..	..	Farm	
So 252	10V, 4.8S, 3.3E	Walt Senecal	1,040	Drl	128	3	10	Becraft-New Scotland limestone	44	Jet	9	..	Farm	Drawdown reported 85 feet after pumping 9 gallons per minute for 1/3 hour.
So 253	10V, 4.7S, 3.4E	J. Cross Estate	960	Drl	357	6	6	Coeymans-Cobleskill limestone	..	..	6	..	Farm	
So 254	10V, 4.2S, 4.4E	J. Nathaway	920	Drl	290	6	..	Pleistocene gravel	34	Jet	24	..		
So 256	10V, 5.1S, 4.7E	Grover C. Guernsey	1,120	Drl	200	6	8	Becraft-New Scotland limestone	..	Force	3	..	Farm	Water reported to be hard.
So 257	10V, 4.7S, 5.6E	Fred Borele	770	Drl	218	6	6	Coeymans-Cobleskill limestone	..	Force	..	..	Dom	
So 259	10V, 3.9S, 5.8E	North American Cement Corp.	860	Drl	580	10	0	Manlius limestone-Schenectady formation	..	..	0.5	..		Water reported to be salty.
So 260	10V, 4.0S, 5.9E	North American Cement Corp.	840	Drl	130	6	130	Rondout-Cobleskill limestone	..	Force	..	..	Com	([g])
So 261	10V, 4.2S, 5.9E	North American Cement Corp.	760	Drl	..	6	..	Rondout-Cobleskill limestone	50	Force	..	..	Dom	Water struck at 80 feet and rose to 50 feet.
So 262	10V, 4.2S, 6.1E	North American Cement Corp.	780	Drl	200	6	50	Rondout-Cobleskill limestone	..	Jet	..	..	Dom	

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So 263	10V, 4.4S, 6.4E	Mr. Spenelo	750	Drl	136	6	136	Pleistocene gravel	..	..	17	..	Dom	Hardpan and clay reported from 0 to 132 feet, then 4 feet of waterbearing gravel. Water reported to contain hydrogen sulfide. Well reported to flow without pumping.
So 264	10V, 4.2S, 5.9E	North American Cement Corp.	780	Drl	220	6	..	Pleistocene till	+4	None	35	..	Dom	Well reported to flow without pumping.
So 266	10V, 5.1S, 6.8E	M. Moseman	1,200	Drl	216	8 to 6	4	Esopus siltstone	126	Force	4	45	Dom	([g])
So 272	10V, 4.3S, 10.3E	Gustaf Van Linden	640	Drl	106	6	100	Schenectady formation	+1	Centrifugal	2.5	..	Farm	Well reported to flow without pumping at rate of 2½ gallons per minute.[g]
So 273	10V, 4.5S, 10.3E	Henry Van Linden	680	Drl	116	6	110	Schenectady formation	..	Suction	10	..	Dom	Clay, hardpan and gravel above rock.
So 274	10V, 4.7S, 10.3E	William Murray	640	Drl	70	6	50	Brayman shale-Schenectady formation	+1	None	5	..	Com	Bedrock reported at 50 feet. Well reported to flow without pumping.
So 275	10V, 4.8S, 10.4E	Bob Young	640	Drl	59	6	59	Pleistocene gravel	12	Jet	25	..	Dom	
So 276	10V, 3.9S, 11.0E	William Van Linden	1,000	Drl	200	6	180	Schenectady formation	..	Turbine	..	..	Dom	
So 277	10V, 3.4S, 11.7E	Willard Wright	1,250	Drl	435	6	85	New Scotland limestone	180	Turbine	3.5	..	Farm	Drawdown reported 250 feet after 3 to 4 hours pumping.[g]
So 278	10V, 4.7S, 10.3E	William Murray	1,250	Drl	40	6	36	Schenectady formation	27	Turbine	8	..	Dom	Dark sand and hardpan reported above shale. Water oily.
So 279	10V, 3.6S, 12.2E	W. Wilber	1,220	Drl	406	6	225	Schenectady formation	150	Force	2	..	Farm	
So 284	10V, 5.0S, 10.7E	Mr. Acker	630	Drl	148	6	..	Pleistocene clay	5	None	..	..		Well does not yield enough water for farm purposes.
So 285	10V, 5.3S, 9.7E	John Fink formerly Borden Company	610	Drl	205	6	205	Pleistocene gravel	6	..	150	..	Com	Water reported to contain hydrogen sulfide. Well reported to level at 60 feet while pumping.
So 287	10V, 4.6S, 8.3E	William G. Brown	1,100	Drl	203	6	19	Becraft limestone	..	..	10	..		Well reported to give yield of 5 gallons per minute at depth of 146 feet.
So 306	10V, 8.1S, 8.0E	S. Flicker	660	Drl	102	6	102	Pleistocene gravel	30	Force	..	55	Farm	Water reported to contain hydrogen sulfide.
So 310	10V, 8.4S, 8.6E	S. Schaeffer	660	Drl	200	6	40		21	Turbine	40	..	Farm	Clay reported to overlie rock.
So 312	10V, 7.3S, 9.1E	S. Schaeffer	680	Drl	119	6	62	New Scotland limestone	70	Force	10	..	Dom	Water reported to be hard and to contain hydrogen sulfide.
So 315	10V, 7.2S, 9.6E	Mrs. H. Ranch	730	Drl	72	6	25	Becraft limestone	6	..	5	..	Farm	

See footnotes at end of table.

Table 6.—Records of selected wells in Schoharie County, New York. (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
So 321	10V, 8.9S, 8.3E	Miss Schell, Blue Gables Cabins	610	Drl	145	6	..	Pleistocene gravel	22	Suction	20	..	Com	Five foot bed of gravel reported to be overlain by 140 feet of clay.
So 322	10V, 8.8S, 7.6E	J. Peek	720	Drl	84	6	7	Onondaga limestone	30	Force	..	50	Dom	
So 323	10V, 9.0S, 7.6E	K. Borsell	690	Drl	150	6	5	Onondaga limestone	40	Force	..	50	Farm	
So 324	10V, 9.4S, 7.6E	R. Loeffler	690	Drl	100	6	37	Onondaga limestone	..	Force	29	40	Dom	
So 326	10V, 8.1S, 0.9E	Mr. Karkerard	1,930	Drl	232	..	97	Hamilton formation	..	..	30	..	Farm	
So 329	10V, 9.4S, 5.4E	J. Prokop	1,240	Drl	213	6	213		..	None	1	..	Farm	Well reported to flow without pumping.[g]
So 334	10V, 10.8S, 7.6E	J. Shepard	680	Drl	48	6	48		..	..	..	..	Dom	Well reported to be 48 feet to rock, but not into it, and to flow without pumping.
So 336	10V, 10.3S, 8.5E	Borden Farm Products	640	Drl	415	10	90	Esopus siltstone	14	Turbine	185	..	Com	Well reported to contain hydrogen sulfide. Drawdown reported 27 feet after 4 hours pumping.[g]
So 338	10V, 10.3S, 10.7E	Mr. Decker	1,720	Drl	104	6	11	Hamilton formation	..	Force	15	..	Farm	Water reported to be hard.
So 339	10V, 11.1S, 8.9E	Rueben Almy	710	Drl	142	6	..	Pleistocene gravel	8	Force	4	..	Com	Drawdown reported 120 feet when pumping 25 gallons per minute. Six percent iron content reported.
So 345	10V, 12.0S, 7.9E	F. Van Aller	650	Drl	177	6	50	Hamilton formation	100	Force	4.5	..	Dom	Driller reports material overlying bedrock is mostly clay.
So 348	10V, 11.3S, 7.5E	Hillview Ranch	650	Drl	500	6	200	Marcellus shale-Onondaga limestone	3	Suction	19	..	Farm	
So 352	10V, 11.3S, 6.1E	Mrs. Westheimer	650	Drl	250	6	60	Hamilton formation	18	..	..	50	Farm	([g])
So 357	10V, 12.5S, 5.3E	L. Shand	710	Drl	80	6	80	Pleistocene gravel	20	Force	..	..	Farm	Water reported to be hard.
So 358	10V, 12.5S, 5.2E	Seward Lewis	720	Drl	145	6	..	Pleistocene gravel	..	None	16	..	Farm	Well reported to flow without pumping.
So 359	10V, 12.5S, 5.2E	Erskine and Erngraham	760	Drl	65	6	..	Hamilton formation	..	Force	..	..	Dom	
So 360	10V, 12.5S, 5.1E	L. Lawyer	780	Drl	100	..	..	Pleistocene clay	80	Force	..	50	Farm	
So 361	10V, 12.4S, 4.7E	Larry Warner	900	Drl	122	6	30		20	Suction	10	..	Dom	
So 362	10V, 12.7S, 3.5E	Mr. Liptock	1,630	Drl	222	6	5	Hamilton formation	5	Force	7	..	Farm	
So 368	10V, 12.7S, 1.9E	R. Greer	1,150	Drl	190	6	..	Hamilton formation	15	Force	..	..	Com	
So 372	10V, 14.5S, 3.9E	G. Hilts	900	Drl	157	6	7	Hamilton fromation	90	Force	7	40	Farm	
So 373	10V, 14.4S, 4.1E	M. Hilts CCC Camp	860	Drl	180	6	..	Hamilton formation	..	None	10	40	Dom	Well reported to flow without pumping.
So 376	10V, 13.1S, 6.1E	R. Weickert	1,100	Drl	103	6	20	Hamilton formation	47	Force	8	..	Farm	
So 378	10V, 12.1S, 9.5E	S. Palmer	840	Drl	186	6	..	Pleistocene sand	27	Jet	35	..	Farm	Quicksand reported in well. Well cannot be used.

See footnotes at end of table.

Table 6.—Records of selected wells in Schoharie County, New York. (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
So 381	10V, 11.5S, 11.2E	L. Dixie	960	Drl	130	6	130	Pleistocene gravel	..	None	160	..	Dom	Well reported to flow without pumping.
So 382	10V, 11.6S, 11.5E	M. Summers	890	Drl	200	6	..	Hamilton formation	8	Force	30	..	PWS	Six percent iron content reported.
So 383	10V, 12.4S, 11.9E	L. Campbell	1,200	Drl	232	6	228	Hamilton formation	..	Force	10	..	Farm	Brown deposit reported in water. Till reported over rock.
So 388	10V, 12.4S, 9.6E	L. and C. Fringo	860	Drl	99	..	..	Pleistocene sand	..	Suction	..	..	Dom	Drawdown 15 feet after 5 minutes pumping with hand pump. Well reported to flow without pumping.
So 392	10V, 13.6S, 10.0E	W. Gerhardt	1,220	Drl	152	6	..	Pleistocene gravel	..	Force	12	..	Farm	Clay and quicksand reported to overlie gravel.
So 394	10V, 14.4S, 10.2E	H. Wilber	1,220	Drl	82	6	..	Pleistocene gravel	0	Force	..	..	Farm	Well reported to flow without pumping when not used for a day.
So 395	10V, 14.5S, 10.3E	B. Campbell	1,240	Drl	76	6	76	Pleistocene gravel	10	Force	8	..	Farm	
So 396	10V, 14.9S, 10.2E	R. Earls	1,190	Drl	107	6	107	Pleistocene gravel	5	Force	10	..	Farm	
So 402	10V, 15.6S, 8.3E	Otto Schuck	1,920	Drl	238	6	5	Onteora formation	98	Turbine	3.5	..	Dom	Water yield reported to be 1½ gallons per minute at 208 feet, and 3½ gallons per minute at 238 feet.
So 406	10V, 15.5S, 5.2E	Breakabeen Cemetery	1,010	Drl	310	6	..	Hamilton formation	90	Force	10	..	Irr	
So 408	10V, 14.9S, 4.9E	Willard Mann	720	Drl	56	6	..	Pleistocene gravel	20	Suction	10	..	Farm	Water reported to be very hard. Drawdown 2 feet when pumping 20 gallons per minute.
So 410	10V, 15.6S, 4.5E	Walhalla Hotel	740	Drl	38	6	25	Hamilton formation	18	Suction	12	..	Com	
So 411	10V, 15.7S, 4.6E	Mrs. Nelson	740	Drl	165	6	21	Hamilton formation	12	Suction	30	..	Dom	
So 414	10W, 3.1S, 0.5E	E. K. Taber	1,270	Drl	150	6	..	Manlius-Cobleskill limestone	..	Force	0.3	..	Farm	Water reported to be hard.
So 415	10W, 2.9S, 0.7E	Francis Masterson	1,380	Drl	101	6	82	Coeymans-Manlius limestone	35	Jet	6	..	Farm	(g)
So 418	10W, 3.9S, 1.6E	Harry Gallup	1,160	Drl	109	6	..	Pleistocene gravel	..	Jet	5	..	Dom	
So 419	10W, 3.5S, 1.9E	George Barber	1,260	Drl	85	6	10	Coeymans-Manlius limestone	..	Suction	..	..	Dom	
So 421	10W, 2.3S, 3.6E	Mrs. C. Panas	1,290	Drl	91	6	69	Schenectady formation	62	Jet	60	..	Farm	Bedrock encountered at 69 feet.
So 424	10W, 5.0S, 1.3E	Norman D. Newcomb	860	Drl	120	6	100	Pleistocene sand	..	..	15	..	Dom	Well reported to flow without pumping at rate of 10 gallons per minute.[g]
So 430	10W, 7.8S, 2.5E	Randall Decker	1,020	Drl	80	6	..	Pleistocene gravel	27	Jet	20	..	Farm	(g)
So 435	11V, 0.5S, 3.2E	Bradley Wood	700	Drl	128	6	78	Hamilton formation	15	Force	10	..	Farm	Water reported to be soft.

See footnotes at end of table.

Table 6.—Records of selected wells in Schoharie County, New York. (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
So 439	11V, 1.0S, 3.1E	H. H. Kniskern	760	Drl	132	6	80	Hamilton formation	10	Force	8	..	Farm	No drawdown reported after 12 hours pumping at 500 gallons per hour.
So 442	11V, 2.1S, 2.1E	W. Snyder	820	Drl	59	..	..	Hamilton formation	3	Suction	7.5	50	Dom	
So 443	11V, 2.2S, 2.2E	Old Schoolhouse	810	Drl	110	6	..	Hamilton formation	..	None	..	..	Dom	Well reported to flow without pumping.
So 444	11V, 2.1S, 2.1E	North Blenheim Creamery Corp.	830	Drl	101	5	..	Pleistocene sand	+40	Turbine	.	50	Com	Well not used; capped; reported to formerly flow at rate of 5 gallons per minute.
So 454	11V, 1.4S, 8.1E	C. W. Ferris	1,920	Drl	172	..	30		..	Force	..	..	Dom	
So 454	11V, 1.4S, 8.1E	C. W. Ferris	1,920	Drl	75	6	30		..	Force	..	..		
So 460	11V, 0.9S, 10.7E	H. Rushmeier	1,040	Drl	194	6	194	Pleistocene deposits	21	Suction	..	..	Dom	Well reported to be drilled 180 feet from bottom of dug well.
So 461	11V, 1.0S, 10.8E	G. Reichert	1,120	Drl	40	6	40	Pleistocene gravel	14	Force	..	..	Dom	Water reported to be soft.
So 462	11V, 0.9S, 11.5E	Clayton D. Losee	1,080	Drl	172	6	172	Pleistocene gravel	..	Suction	..	..	Com	Well reported to flow without pumping.
So 463	11V, 0.9S, 11.6E	D. Tallman	1,070	Drl	34	6	34	Pleistocene gravel	10	Suction	15	..	Dom	Water reported to have an iron taste.
So 464	11V, 0.9S, 11.7E	Mr. Eberling, Livingston Hotel	1,070	Drl	36	6	36	Pleistocene gravel	12	Suction	15	..	Com	Water reported to be soft.
So 465	11V, 0.9S, 11.8E	Miss Scharf	1,080	Drl	218	6	218	Pleistocene gravel	6	Centrifugal	6	..	Dom	Water reported to be high in iron content. Clay reported to lie above gravel.
So 467	11V, 1.7S, 9.7E	Tomkin's Sawmill	1,880	Drl	172	6	105	Onteora formation	132	None	4.5	..	Com	Pump not yet installed.
So 470	11V, 2.7S, 7.2E	Mr. Cook	1,900	Drl	72	6	26	Onteora formation	21	Suction	15	..	Farm	Water reported to be soft.
So 471	11V, 2.8S, 7.1E	S. S. Brown Milk Plant	1,940	Drl	142	6	40	Onteora formation	..	..	150	..	Com	Well abandoned. No drawdown after pumping 150 gallons for 3 hours.
So 473	11V, 3.0S, 6.2E	Stanley Mace	1,980	Drl	112	6	..	Onteora formation	..	..	7	..	Farm	Water reported to be hard.
So 474	11V, 2.2S, 4.7E	Fastert Brothers	1,920	Drl	228	6	15	Gilboa-Hamilton formation	190	Force	40	47	Farm	
So 477	11V, 3.4S, 3.5E	B. Scutt	1,880	Drl	327	6	100	Gilboa-Hamilton formation	227	Force	..	48	Farm	
So 489	11V, 3.9S, 6.1E	A. Haskin	1,800	Drl	142	..	9	Onteora formation	30	Force	30	..	Farm	Water reported to be soft.
So 500	11V, 6.4S, 2.1E	W. M. Stryker	970	Drl	89	6	6	Pleistocene gravel	..	Force	6.5	..	Farm	Water reported to be hard.
So 505	11V, 7.4S, 2.4E	F. M. Crosby	980	Drl	44	6	..	Gilboa formation	22	Suction	4.5	..	Dom	
So 510	11V, 8.3S, 1.4E	W. Schwoerer	1,680	Drl	160	6	4	Gilboa formation	..	Force	..	..	Dom	Water reported to be hard.
So 513	11V, 8.1S, 3.4E	A. G. Osborne	1,200	Drl	82	6	..	Gilboa-Hamilton formation	..	Turbine	4	..	Com	Well not used; not enough water.

See footnotes at end of table.

Table 6.—Records of selected wells in Schoharie County, New York. (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
So 522	11V, 8.2S, 5.6E	G. W. Case Stock Farm	1,340	Drl	100	6	..	Pleistocene gravel	13	Suction	15	..	Farm	
So 523	11V, 7.6S, 6.4E	Charles Wycoff	1,440	Drl	180	6	180	Pleistocene gravel	15	Suction	20	..	Dom	
So 524	11V, 7.6S, 6.3E	Eva Lovell	1,400	Drl	50	6	50	Pleistocene gravel	18	Suction	20	..	Farm	
So 525	11V, 7.8S, 6.8E	George Cook	1,390	Drl	182	6	180	Pleistocene gravel	11	Suction	25	..	Com	Clay, hardpan and quicksand reported to overlie gravel.
So 532	11V, 7.6S, 9.1E	McDermott Brothers	1,540	Drl	300	6	100	Onteora formation	..	Turbine	..	47	Com	
So 536	11V, 6.8S, 10.2E	W. McCafferty	1,760	Drl	138	6	10	Onteora formation	17	Force	..	58	Farm	Water reported to be soft.
So 538	11V, 6.2S, 9.8E	Cleveland Farm	2,140	Drl	90	6	27	Onteora formation	21	Jet	10	..	Farm	
So 539	11V, 7.6S, 10.0E	Otis C. Wright	1,900	Drl	140	6	..	Onteora formation	42	Suction	4	..	Farm	Water reported to be soft.[g]
So 540	11V, 7.7S, 9.7E	Burden C. Wright	1,800	Drl	67	6	23	Onteora formation	20	Force	24	..	Farm	Water reported to be corrosive.
So 541	11V, 8.6S, 9.6E	Mrs. M. Sens	1,900	Drl	136	6	133	Onteora formation	90	Force	10	..	Dom	Water reported to be soft.
So 549	11V, 0.2S, 4.4W	F. Laubmeier	1,620	Drl	115	6	22	Gilboa formation	17	Suction	20	44	Dom	
So 561	11V, 1.9S, 7.5W	H. Farrell	1,760	Drl	95	6	48	Gilboa-Hamilton formation	..	Force	..	48	Farm	Water reported to flow without pumping.
So 564	11V, 2.0S, 8.2W	Louis Burger, Jr.	1,850	Drl	300	6	10	Onteora formation	55	Force	..	..	Dom	
So 574	11V, 3.4S, 1.4W	C. Eklund	1,920	Drl	290	6	100	Onteora formation	133	Force	10	..	Farm	Water reported to be soft.[g]
So 577	11V, 3.2S, 3.6W	Butler Brothers	1,760	Drl	58	6	58	Pleistocene gravel	22	Force	..	48	Farm	
So 590	11V, 6.0S, 1.3W	C. E. Andrews	2,020	Drl	90	6	45	Onteora formation	25	Force	..	..	Farm	Water reported to be hard.
So 595	11V, 6.2S, 3.7W	E. Brenn and Son	1,880	Drl	191	6	30	Onteora formation	35	Jet	..	..	Farm	Water reported to be hard.[g]
So 598	11V, 4.8S, 6.1W	Stamford Country Club	1,980	Drl	240	8	7	Onteora formation	..	..	..	..	Irr	
So 599	11V, 5.1S, 6.2W	Stamford Country Club	1,900	Drl	42	8	7	Onteora formation	..	..	30	..	Irr	Water reported to flow without pumping.
So 608	11V, 1.6N, 10.6W	L. Hillis	1,400	Drv	30	1¼	..	Onteora formation	22	Suction	..	..	Dom	Well was dug 15 feet. Pipe was then driven 15 feet deeper.[h]
So 609	10V, 5.7S, 8.3E	M. Southard	....	Drv	19	1¼	..	Pleistocene gravel	10	Suction	10	..	Dom	Well is located at Middleburg Air Field.[h]
So 610	10V, 11.6S, 8.1E	B. Deertz	642	Drv	20	1	..	Pleistocene gravel	17	Suction	..	..	Dom	([h])
So 611	10V, 11.8S, 8.2E	J. Nohrwold	642	Drv	..	1¼	..	Pleistocene gravel	8	Hand	..	..	Farm	Reported log for 7 feet reads: 0 - 3 feet clay, 3 - 7 feet gravel.[h]
So 612	10V, 11.8S, 6.9E	F. Bohringer	....	Drv	18	1¼	..	....	..	Hand	..	50	Dom	([h])
So 613	10V, 11.8S, 6.4E	J. Youmans	....	Drv	17	1¼	..	Pleistocene gravel	2	Suction	..	50	Farm	([h])
So 614	10V, 11.9S, 5.6E	E. Barber	695	Drv	18	1¼	..	Pleistocene gravel	6	..	..	50	Dom	([h])

See footnotes at end of table.

Table 6.—Records of selected wells in Schoharie County, New York. (Continued)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
So 615	10V, 12.3S, 5.5E	J. Durie	....	Drv	12	1¼	..	Pleistocene till	4	Hand	..	50	Farm	(h)
So 616	10V, 12.6S, 12.6E	W. Newhouse	1,167	Drv	16	1	..	Pleistocene gravel	7	Suction	..	..	Farm	(h)
So 617	10V, 13.6S, 10.1E	H. Hansen	1,100	Drv	58	1¼	..	....	10	Hand	..	..	Farm	Water reported to have a "barnyard" odor.[h]
So 618	10W, 6.1S, .7E	Gallupville Fire Company	800	Drv	19	1¼	..	Pleistocene gravel	..	Pitcher	..	..	Dom	(h)
So 619	11V, .7S, 3.3E	H. Van Wormer	755	Drv	25	1	..	....	12	..	..	..	Farm	(h)
So 620	11V, 7.2S, 2.6E	C. N. Richtmyer	990	Drv	12	1¼	..	Pleistocene sand	..	Suction	4½	50	Dom	(h)
So 621	10V, 4.7N, 6.0W	P. Seiler	1,000	Dug	12	36	..	....	3	Force	..	..	Dom	Well is cased with stone.[h]
So 622	10V, 4.3N, 5.1W	W. M. Kling	820	Dug	8	42	..	....	4	Force	..	..	Dom	Well is cased with stone.[h]
So 623	10V, 3.0N, 4.1W	N. Belenie	1,360	Dug	30	60	..		8	Hand	..	..	Dom	Well is cased with stone.[h]
So 624	10V, 2.9N, 8.5W	O. J. Neal	1,380	Dug	15	30	..		13	Hand	..	..	Dom	Well is cased with stone; sometimes well goes dry.[h]
So 625	10V, 2.3N, 5.2W	A. J. Winne	1,420	Dug	25	..	..		8	Hand	..	50	Farm	Well is cased with stone; sometimes well goes dry.[h]
So 626	10V, 1.8N, 2.4W	J. Morozow	1,200	Dug	37	8	..		0	Force	..	..	Dom	After well was dug 8 inch pipe was installed and sides were filled with concrete. Water level is always at the surface.[h]
So 627	10V, 1.8N, 1.2W	C. Kennedy	1,150	Dug	24	48	..	....	17	Hand	..	..	Dom	Well is cased with stone.[h]
So 628	10V, 1.6N, 3.6W	S. C. Wright	1,500	Dug	20	36	..		17	Hand	..	..	Dom	Well is cased with stone.[h]
So 629	10V, 0.6N, 1.6W	J. A. Jansson	1,120	Dug	17	36	..		12	Force	..	..	Dom	Well is cased with stone.[h]
So 630	10V, 0.8N, 5.7W	F. Mereness	1,270	Dug	13	36	..	Pleistocene till	6	Force	..	..	None	Water reported to have an oily taste. Well is cased with stone.[h]
So 631	10V, 1.1N, 5.1W	J. Tryon	....	Dug	12	..	..		5	Hand	..	45	Dom	(h)
So 632	10V, 0.5N, 1.9E	G. Smullen	1,360	Dug	15	48	..		..	Pitcher	..	..	Dom	Seventy gallons per day are ordinarily obtained from this well.[h]
So 633	10V, 0.5N, 3.6E	R. Foster	1,160	Dug	14	..	..	Pleistocene till	7	Suction	..	..	Dom	(h)
So 634	10V, 0.5N, 5.7E	C. Edholm	1,160	Dug	20	..	..	Pleistocene till	10	Suction	..	..	Dom	(h)
So 635	10V, 1.5N, 8.4E	E. Degroff	1,020	Dug	22	72	..	....	10	Bucket	..	..	Farm	(h)
So 636	10V, 0.5N, 10.1E	J. MacDonald	620	Dug	20	48	..	....	..	Pitcher	..	..	Dom	(h)
So 637	10V, 0.7N, 9.7E	J. MacDonald	760	Drl	235	6	84		..	Force	30	55	Farm	Water reported to have salty taste. Reported log is 89 feet of glacial till and into sandstone and shale.[h]
So 638	10V, 0.6N, 10.7E	B. Blair	620	Dug	25	48	..	....	..	Force	25	..	Dom	(h)

See footnotes at end of table.

Table 6.—Records of selected wells in Schoharie County, New York. (Concluded)

Well number	Location[a]	Owner	Altitude above sea level (feet)[b]	Type of well[c]	Depth (feet)	Diameter (inches)	Depth to bedrock (feet)	Geologic subdivision	Water level below land surface (feet)[d]	Method of lift[e]	Yield (gallons per minute)	Temperature (°F.)	Use[f]	Remarks
So 639	10V, 0.7N, 11.8E	W. Hewett	600	Dug	17	48	..		7	Pitcher	..	..	None	Water reported to contain hydrogen sulfide.[h]
So 640	10V, 2.9N, 6.7W	Village of Sharon Springs	1,340	Drl	300	..	..		300	Force	300			([h])
So 641	11V, 1.8S, 5.8W	C. Buhl	1,959	Dug	19	24	..		16	Hand	..	..	Dom	Well is cased with stone.[h]
So 642	11V, 1.2S, 7.5W	H. C. Herman	1,800	Dug	11	96	..	Pleistocene gravel	5	Suction	..	..	Dom	Well is cased with stone.[h]
So 643	11V, 2.0S, 6.4W	A. Klepac	1,980	Dug	35	72	..	....	25	Hand	..	..	Dom	Well is cased with stone.[h]
So 644	11V, 3.1S, 1.0W	A. Eklund and Sons	1,980	Dug	26	36	..	....	23	Suction	..	..	Dom	Well is cased with stone.[h]
So 645	11V, 4.0S, 3.5W	F. C. Mabey	1,640	Dug	..	36	..	....	3	Hand	..	42	Dom	Well is cased with stone.[h]
So 646	10V, 0.9S, 7.3W	E. Vanderwerker	....	Dug	22	48	..	Pleistocene till	11	Hand	..	..	Dom	Well is cased with stone.[h]
So 647	10V, 3.7S, 12.3E	W. Wilber	1,220	Dug	18	36	..	....	5	Hand	..	..	Dom	Well is cased with stone.[h]
So 648	10V, 0.1N, 8.8E	C. Haegen	660	Drl	219	6	56		..	Force	..	..		Water has too salty a taste to drink.[h]
So 649	10V, 5.7S, 0.2W	Village of Cobleskill	840	Drl	60	..	60	Pleistocene sand	..	Force	2	..		Well abandoned.[h]
So 650	10V, 6.2S, 0.5W	Village of Cobleskill	835	Drl	92	..	..	Pleistocene sand and clay	..	Force	2	..		Well abandoned.[h]
So 651	10V, 5.2S, 10.7E	Village of Schoharie	620	Dug	14	36	..	Alluvium gravel	..	..	40+	..	PWS	Well cased with stone.[h]

[a] For explanation of location symbols see section, "Methods of Investigation."
[b] Approximate altitude from topographic map.
[c] Type of well: Drl, drilled; Drv, driven.
[d] Reported average water level.
[e] For explanation of methods of lift and pumping equipment see section, "Ground-water recovery."
[f] Use: Dom, domestic; Com, commercial; Ind, Industrial; PWS, public water supply.
[g] For chemical analyses see table 4.
[h] Records for wells So 608 to So 651 were collected after Plate 1 was printed and, therefore, do not appear on the map. These wells may be located using the coordinates shown in the location column and on Plate 1.